1. General Background - Explain purpose of report, it's structure, etc.

USAEHA response: Accepted in the Executive Summary as well as the main body of the final report. You will note a more comprehensive discussion of the report's structure.

2. Air Quality Monitoring/Modeling - Discuss monitoring instruments and methods used, sites/locations, sampling periods, results obtained etc; also characterize any modeling approaches used and results.

USAEHA response: Accepted. A full discussion of the instrumentation, selected sampling methodologies, and the scope of the study as concerns air quality monitoring/modeling is found in Appendix B.

3. Potential Health Effects - Present concise discussion of potential toxic effects associated with various pollutants detected by monitoring efforts - including noting of relevant air standards, RfC's or other available guideline values; discussion of exposure-effect relationships as appropriate, especially for pollutants estimated (by monitoring or modeling) to exceed standards, RfC's, other guideline values; and identify/discuss special risk groups.

USAEHA response: Accepted. relevant and related toxic effects has been included in the final report. The Troop Exposure Assessment Model (TEAM) modeling effort on the Intergraph GIS also incorporates the relevant and related toxicity values in its risk assessment algorithms. Populations at risk have been defined more clearly.

4. Exposure Assessment - Considering activity patterns (troop movements, etc.), derive scenarios (ii at all possible) for likely exposures of individuals in different demographic groups (U.S. military; U.S. Civilians; Allied troops; local Kuwaiti/Saudi civilians, other nationals, etc.) to various pollutants monitored at specific locations (or across locations). Characterize frequency/duration of exposures (both acute and extended) to pollutants of most concern (e.g., PM_{10}) for various subpopulation groups.

USAEHA response: Accepted in part. The fixed site risk assessments include consideration of different demographic groups as limited by the direction of the Tri-Service Task Force and the scope of this study (i.e., DOD troops and civilian employees). The TEAM modeling effort includes provisions to assess risk at different locations, at different time periods due to movement of the exposed populations. A qualitative assessment of the PM_{10} exposures for the exposed population has ken included. The data presented in this study would be useful in assessing the health risk of the other populations as stated in your comment. The data will be made available to the scientific community to facilitate such assessments.

5. Risk Characterization. Drawing upon information contained in the preceding sections (2, 3, and 4) above provide an overall health risk assessment, stating likelihood that different subpopulation groups would experience particular types of effects due to individual substances or pollutant combinations. Estimate numbers of persons in various subpopulation groups likely to be or have been at risk for particular effects, given activity patterns and associated - of exposure.

USAEHA purpose; Accepted in TEAM project is to provide exposure assessment information as required by Public Law 91-102. A study of the trends in exposures based upon the TEAM modeling might perhaps provide a means to estimate sub-population effects as your comment requests. Otherwise, without a full disclosure of the order of battle of the troop units, and a detailed analysis of the activity patterns associated with a representative sample of each type of maneuver unit, it seems somewhat impossible to further define the associated health risks other than on a regional basis. It must also be remembered that health risk assessment is indeed a probablistic methodology which may predict likely health effects; but, the paradigm cannot predict individual health outcomes. Rigorous epidemiological investigation of selected subpopulations may offer the only alternative for eliciting effects groupings with any statistical validity or true meaning.

Particular attention should be paid to clarifying the purpose of the report (is it actually aimed at assessing risk to Allied Troops, Kuwaiti/Saudi civilians, and/or other nationals, as well as U.S. Military and non-Military personnel). Potential risks posed could be different for local civilian populations including more heterogeneous subpopulations (very young, very old, etc.) than U.S. groups in the region. It appears from the analyses presented in the draft report that exposures to elevated PM would be of most concern as possibly posing notable health risks although the HRA only reports data for PM and lead from among the "criteria" air pollutants. Some explanation of why other major pollutants (SO_2, O_3, NO_X and CO) were not monitored would be useful.

With regard to PM exposures, for the monitoring period, May to September, maximum PM_{10} values at each monitoring site ranged from 6.2 $\mu g/m^3$ to 2216.2 $\mu g/m^3$. The plotted PM_{10} data were replotted and are shown in the attached Figures A and B, which show reference lines for the relevant NAAQS, Alert Level and Significant Harm Level. Based on these plots for this period, PM_{10} concentrations routinely exceeded the U.S. NAAQS (24-hour standard of 150 $\mu g/m^3$) while frequently exceeded the Alert Level or several times, even exceeded the Significant Harm Level. Actually, the monitoring data show that PM_{10} concentration levels exceeded the Significant Harm level (600 $\mu g/m^3$) at all monitoring stations at least once in this period. No such comparisons or observations are made in the draft HRA. U.S. EPA standards, e.g., 24-hour and annual standards for PM,, are listed in Table B-4-1, but no subsequent summaries, tables, or graphs relate measured values or modelled exposure estimates to those standards or potential associated health risks that might occur at the Alert,

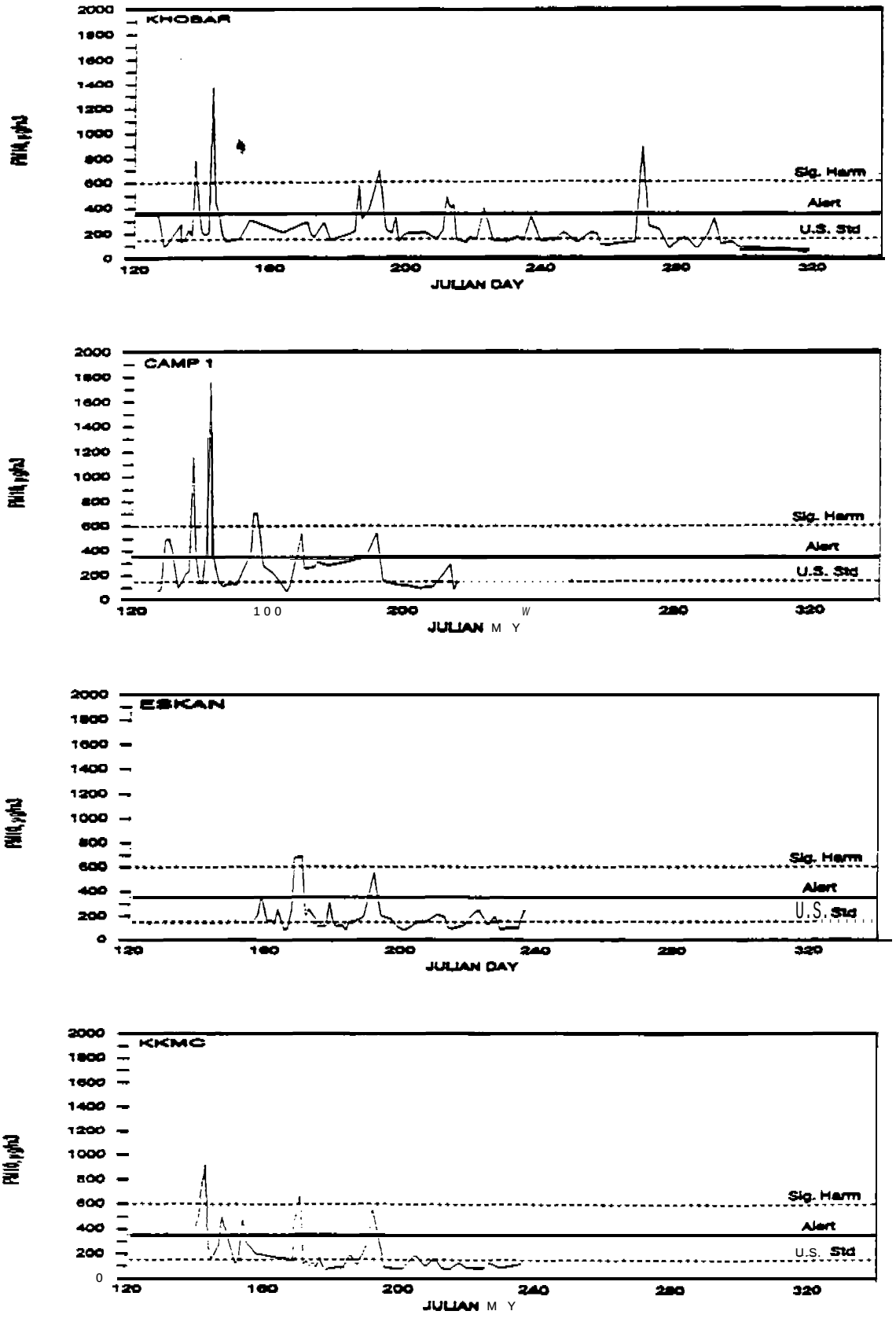

Figure A. Saudi Arabian monitoring stations.

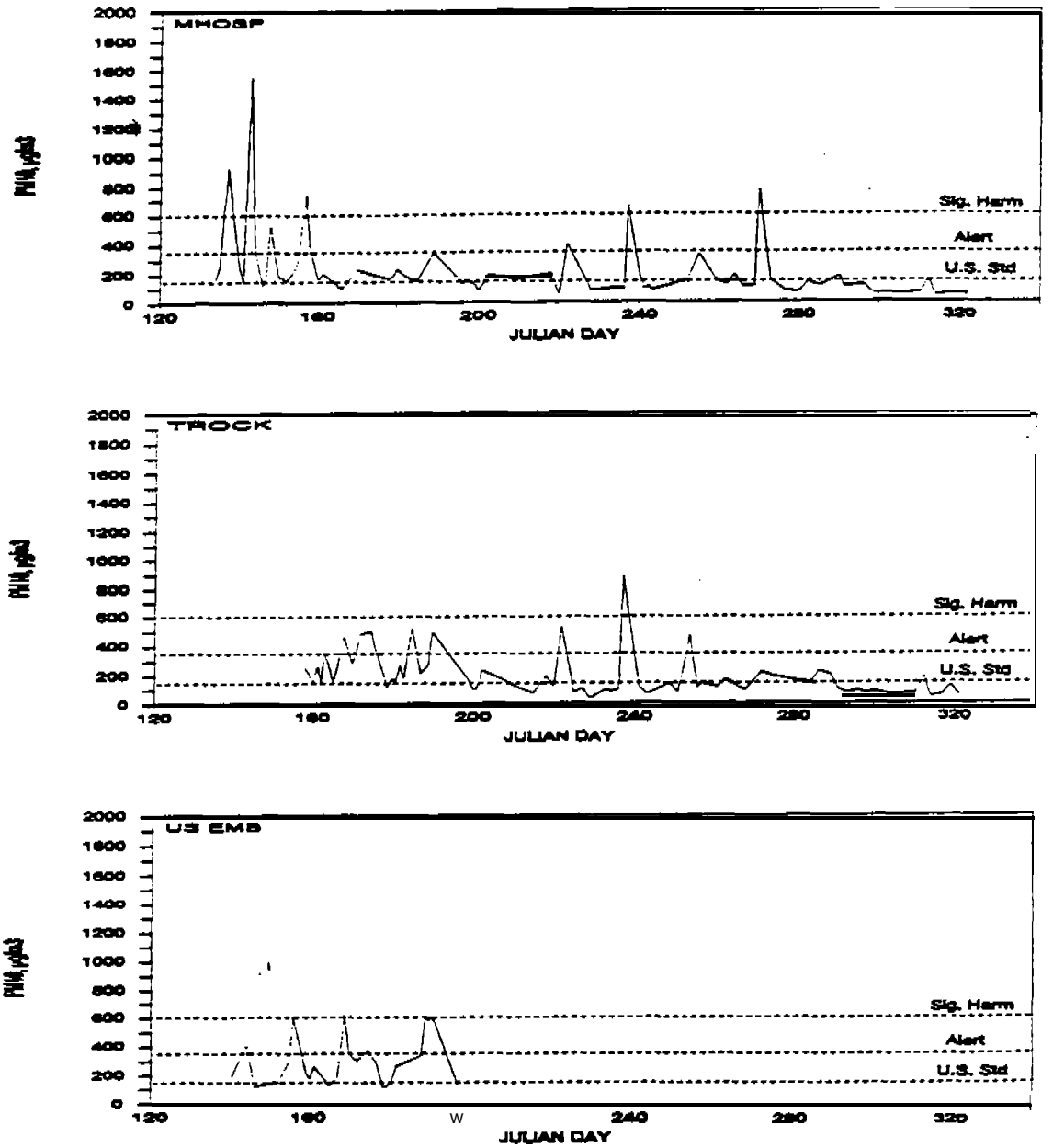

Figure B. Kuwaiti monitoring stations.

COMPARISON OF POLLUTION STANDARD INDEX (PSI) VALUES WITH POLLUTANT CONCENTRATIONS, HEALTH DESCRIPTORS, GENERAL HEALTH EFFECTS, AND CAUTIONARY STATEMENTS

Index Value	Air Quality Level	POLLUTANT LEVELS: PM (24-h), µg/m³	SO_2 (24-h) µg/m³	CO (8-h) ppm	O_3 (1-h) ppm	NO (1-h) ppm	* Health Effect Descriptor	General Health Effects	Cautionary Statements
								Acutely incapacitating symptoms experienced by significant portions of the population, especially by persons undergoing light exercise; health status of particularly vulnerable cardiopulmonary subjects mry be compromised.	Same recommendations as for Emergency Level.
500	Significant Harm	600	2,620	50	0.6 - 2.0				
							Hazardous	Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keep windows and doors closed, minimize physical exertion, and avoid traffic.
400	Emergency	500	2,100	40	0.5	1.6			
							Hazardous	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly end persons with existing diseases should stay indoors and avoid exertion. General population should avoid outdoor activity.
300	Warning	420	1,600	30	0.4	1.2			
							Very Unhealthful	Significant aggravation of symptoms and decreased exercise tolerance in ptrronr with heart or lung disease, with widespread symptoms in the healthy population.	Elderly end persons with existing diseases should stay indoors end reduce physical activity.
200	Alert	350	800	15	0.2	0.6			
							Unhealthful	Mild aggravation of symptoms in susceptible ptrronr, with irritation rymplomr in the healthy population.	Persons with heart or respiratory ailments should stay indoors rod reduce physical activity.
100	NAAQS	150	365	9	0.12	--[a]			
							Moderate		
50	50% of NAAQS	75	80[b]	4.5	0.06	--[a]			
							Good		
0		0	0	0	0	--[a]			

[a] No index values reported at concentrations below those specified by "Alert Level" criteria.
[b] Annual average primary NAAQS.

Warning, Emergency, and Significant Harm levels, which are quite pertinent here for PM_{10}. See attached table of Pollutant Standard Index (PSI) values related to PM_{10} and other criteria air pollutants.

USAEHA response: tration plots in the final report have been revised to include the respective NAAQS and significant harm threshold values.

On page 35 (paragraph XII.B) the report does state that the results of air quality modeling for acid gases, sulfur dioxide, and particulate matter (less than 10 μm in diameter) predicted levels that "would exceed current EPA ambient air quality standards and could result in significant morbidity/mortality under the specified conditions." Even if the production of particulate matter is the result of wind-blown sand and not that of the oil well fires, as proposed in the report, this risk from PM,,, should still be more fully addressed. The report makes this recommendation (page 48, paragraph XV.C) but there are not sufficient data in the report to determine the potential risk based on information presented in the present draft document. Of crucial importance is the need to identify subpopulations likely to be at increased risk for adverse effects of PM (e.g., elderly persons over 65 years old, persons with preexisting cardiopulmonary diseases such as asthma, chronic bronchitis, etc., and possibly very young infants). Also characterize the extent to which such individuals were present or exposed to PM or other pollutants. Assuming that such special risk individuals were screened out or otherwise excluded from U.S. military or civilian personnel (including dependents) in the Saudi Arabia/Kuwait area, then much lower potential risk was posed by the PM, etc. However, such persons might have been among exposed Kuwaiti/Saudi civilian population groups thus posing a different (increased) risk picture for them. Sorting out such potential risk will be exceedingly difficult, if not impossible, given the chaotic situation that existed and problems with even trying to estimate how many people of what age or physical condition were located in particular places and for what periods of time.

USAEHA response: s Noted. ion of the potential health effects of PM_{10} has been included in the final report. The population characterized in this assessment has been clarified. It is DOD troops and DOD civilian employees.

Regarding the risk assessment process for non-carcinogenic effects, the terminology for oral reference dose (RfD) and inhalation reference concentration (RfC) seems to be confused and intertwined at times. Since this is a risk assessment that involves primarily exposure by inhalation, the relevant reference value for the inhalation route would be the RfC; but, the draft text often refers to RfDs in the Executive Summary when RfC should be used.

USAEHA response: Accepted. The terms RfD and RfC have been appropriately used in the final report.

B. Specific Comments

Pages 2. 12. 45. B-36: The draft report contains apparently conflicting statements that create confusion over the number of monitoring sites. Page 2 states there were initially 10 sites, of which two were abandoned very early. Page 12 (c, line 12) states there were 8 sites. However, page 45 (B. Air Pathway Analysis, line 4) later states 10 sites as does page B86 (IX, Conclusions, A, line 4). This should be standardized or better explained.

USAEHA response: Accepted. Clarification of the sampling site numbers and locations has been included.

Page 7. 2nd Paragraph penultimate sentence: The difference between RfDs (oral exposure and RfCs (inhalation exposure) should be explained here. See comment below for Page 21 for appropriate RfC definition.

USAEHA response: Accepted and incorporated in the final report.

Page 8. 1st Paragraph. Lines 8-12: s cancer risk should be explained here.

USAEHA response: t e d .

Page 8. 2nd Paragraph. Line 2: Change to read "... daily intake by its RfD or RfC (for this ...")

USAEHA response: Accepted and changed.

Page 17. 18: CF should be 10^3 µg/mg for the equations used.

USAEHA response: d .

Page - st Paragraph. Line 4: Change to read "... by the EPA RfD/RfC Work Group". Also, in Line 6 explain that an RfD "estimate of a daily oral exposure ...". Then add new next sentence(s) to provide definition for an RfC as an analogous inhalation reference value. Official RfC definition is as follows: The RfC is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure (in µg/m^3) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

USAEEIA response: Accepted and changed.

Page 21. 1st Paragraph, Line 12: Delete "/safety". Safety factors are not the same as uncertainty factors and ate not part of the RfD or RfC m-logy.

USAEHA response: d .

Page 21. 3rd Line from Bottom of Page: 'In many instances the chemical may only be a carcinogen by one route... ". This is not EPA policy. If it is'a carcinogen by one route it is typically assumed to be carcinogenic by all routes. However, potency may admittedly be so low by one route that effects are undetectable due to low absorption, etc. Perhaps revise the sentence to read: "In many instances, the chemical may only pose appreciable carcinogenic risk via one route of exposure . .."

USAEHA response: Noted.

Page 22. 1st Paragraph: Regarding the use of oral exposure to estimate risk from dermal mute: This leads to an unacceptable degree of uncertainty. Dermal exposure might induce skin cancer [B(a)P is an example]. If it is a site of contact carcinogen, the potency may be much different by each route since the target tissue is different. Additionally, skin absorption bypasses the liver. If there are strong first pass effects, the potency can differ considerably between the oral and dermal routes.

USAEKA response: Noted. We concur that the use of oral exposure to estimate risk from the dermal route is fraught with uncertainty. Current EPA guidance found in the Dermal Exposure Assessment: Principles and Applications Interim Report, EPA/600/8-91/011B, dated January 1992, recommends on page 10-9 that assessors use the oral factors and emphasize the uncertainty inherent in use of this approach.

Page 37. Line 15: "When the risk reaches below 1E-4, ..." should read "when the risk reaches or exceeds 1E-4, ..." Note that 1E-6 is a smaller number (i.e., is below 1E-4).

USAEHA response: Accepted and changed.

Page 40. 5th Paragraph: Uncertainty factors are not the same as safety factors and do not give a ten-fold margin of safety, i.e., permit a hazard quotient or hazard index in the 1 to 10 range. The uncertainty about the RfD or RfC is half an order of magnitude above and below the stated value, but this uncertainty is not a safety range. This uncertainty does not justify characterizing hazard indices of 2 and 4 as being within the margin of safety, as stated on pages 39-40 (Section B.3). A 10-fold uncertainty factor for the use of subchronic study data should also be included.

USAEKA response: Noted and changed as appropriate.

Pages A-2-3 through A-2-53, Tables A-2-2 through A-2-52: Make the following changes- (1) change the column heading "RfC" to "RfD" in both the Volatiles and Metals parts; (2) change the toluene RfC value from 2.0E+O to 4E-1 since this is the verified value on IRIS and recalculate the hazard index; (3) put brackets [ ] around the RfC values for m-xylene, pxylene, and o-xylene since these are not Agency verified values and are not on IRIS but rather are provisional numbers derived from either the Health Effects Assessment Summary Tables (HEAST Tables) or Agency health assessment documents; also use a footnote to define the brackets as indicative of provisional RfC values; (4) indicate that the RfC value for chromium is a provisional value by using brackets since no verified value is available; and (5) change the RfD footnote at the bottom of the page to read "RfC = Inhalation Reference Concentration. "

USAEHA response: Accepted, all values in the final report are current as of December 1993.

For the noncarcinogenic hazard index, RfD rather than RfC values were evidently divided into the inhaled concentration. This is unacceptable since this constitutes a route extrapolation without any pharmacologic or toxicokinetic basis. Also, the Same intakes as shown on the tables cannot be derived using the formulas such as those shown on Page 17

USAEHA response: Noted. The intakes in question were calculated using 'Risk Assistant' which has a flaw in the computation algorithms when dealing with less than 24 hours of exposure/event. We had entered exposure event durations for both outdoor and indoor calculations which totaled 24 hours. The computer program will not recognize combinations of exposure events which total a 24 hour event. It takes each exposure event and calculates an adjusted 24 hour exposure which when considering two differing exposures results in a 48-hour exposure event occurring in a 24 hour period. This is an oversimplification of the process, but describes how you might not have been able to calculate the Same intake values. For the final report we have switched to a Lotus based spreadsheet for these calculations.

Pages A-2-: through A-2-W Tables A-2-56 through A-243: Make the following changes: (1) change the arsenic RfD value from 1E-03 to 3E-4 and the cadmium value from 1E-03 to 5E-4 to be consistent with Agency verified IRIS values and recalculate the hazard quotient; (2) change the chromium RfD value from 2E-02 to 5E-3 indicative of the Agency verified value on IRIS for chromium VI; and (3) indicate the provisional nature of the mercury, vanadium, and zinc RfD values by including them in brackets with a footnote defining the brackets. Repeat these changes for all similar entries in this table and all other affected tables.

USAEHA response: Accepted. Changes checked and annotated appropriately. The values used in the final report are current as of December 1993.

Pages A-3-5, Table A-3-2: Change the title to "Oral Reference Doses (mg/kg/day) and Inhalation References Concentrations (mg/m^3). Also, change column headings: replace "Oral" with RfD, and "Inhalation" with RfC. Make the following changes under the "ORAL" column: (1) for arsenic, change 1E-3 to 3E-4; (2) for cadmium, change 1E-3 to 5E-4; (3) for chromium VI, change 2E-2 to 5E-3; (4) for mercury, vanadium, and zinc bracket 3E-4, 7E-3, and 2E-1, respectively. Under the "INHALATION" (i.e., "RfC") column, make the following changes: (1) for mercury change N/A to 3E-4; (2) for toluene change 2E+O to 4E-1; and (3) for m,p-xylene and o-xylene, bracket 2E-1 and 2E-1, respectively, to show the provisional nature of these values.

USAEHA response: Accepted, the values used in the final report are current as of December 1993.

Page A-3-7, 2nd Paragraph: Add a sentence indicating the verified arsenic RfD on IRIS is equal to 3E-4. Also, correct incomplete sentence starting on Line 10 of Benzene discussion, i.e., put a comma after "tract" and do not capitalize "although."

USAEHA response: Accepted, current values as of December 1993 used and discussion corrected.

Page A-3-8, 2nd Paragraph: Add a sentence indicating the verified beryllium RfD on IRIS is equal to 5E-3.

USAEHA response: Accepted, current values as of December 1993 used.

Page A-3-9: Add reference to EPA CO National Ambient Air Quality Standards (NAAQS), i.e., 35 ppm for 1 hr and 9 ppm for 8 hours.

USAEHA response: Accepted. Reference added.

Page A-3-10 1st Paragraph: Add a sentence indicating the verified hydrogen sulfide RfC on IRIS is 9E-4.

Accepted, response: current values as of December 1993 used.

Page A-3-10, Line 6 in Hydrogen Sulfide paragraph: Correct incomplete sentence. Also, correct incomplete sentence in line 10 of Lead paragraph.

USAEHA response: Accepted and corrected.

Page A-3-13. Last line: Add text to indicate the verified toluene RfC on IRIS is equal to 4E-1.

USAEHA response: Accepted, current values as of December 1993 used.

Page A-3-14: of NO_2 effects is erroneous/outdated needs to be revised using evaluations contained in EPA's recently revised NO, Air Quality Criteria Document (see summary materials being sent under separate cover).

USAEHA response: Noted.

Page A-3-14. 1st Paragraph last sentence: Change to read "chronic and subchronic provisional oral reference dose..."

USAEHA response: Accepted, current values as of December 1993 used.

Page A-3 15. 3rd Paragraph last sentence: Change to read "... has developed a provisional oral RfD..."

USAEHA response: Accepted, current values as of December 1993 used.

Page A-3-16. 1st Paragraph last sentence: e t o read "and a provisional inhalation Rfc of ..."

USAEHA response: Accepted, current values as of December 1993 used.

Pages A-3-16 References: No full citation (date, etc.) is given for Klassen et al. reference, listed only as 3rd edition. Actually, the full citation is: Klassen, C.D., Amdur, M.O. and Duoll, J. Casarett and Duoll's Toxicology: the Basic Science of Poisons, 3rd Edition, New York, NY (1986). However, that 1986 edition is badly out-of-date and the newer (1991) edition should be used and cited as follows: Amdur, M.O., Duoll, J., and Klassen, C.D. Casarett and Duoll's Toxicology: The Basic Science of Poisons, 4th Edition, Pergammon Press, New York, NY, 1991.

USAEHA response: Accepted, citation corrected.

Page B-48 b.. Line 7: Shouldn't this read as "on the backup sample" and not "actual sample"?

USAEHA response: Accepted, the sentence has been corrected.

Page B-53, Table B-8: Low Vol Flow rate 1 to 5 L/min, text implies sample rate was 4.9 L/min. If so, then results are not likely directly comparable to those obtained at 5.0 L/min. Why the difference? Were some samples taken at 1 L/min?

USAEHA response: Low flow TO13 samples were collected at flow rates ranging from 1.1 to 4.5 liters per minute. For all of the low flow TO13 samples, the associated pollutant masses were below the analytical detection limit.

Page B-55, c., Line 12: Were the 1988 values for the metals from samplers that would be expected to give samples equivalent to those collected in 1991? This question should be addressed since a comparison is made that implies the fires do not increase the metals' content of the particulates in the ambient air. Also, how did Saudi Aramco's Continuous PM_{10} samples compare to Army samples for metals content?

USAEHA response: Noted. The 1988 metals data were the only database which the USAEHA had to provide any comparison against the data collected in 1991. The USAEKA recently was provided a copy of a journal paper entitled "Concentration of Chromium and Copper in Air Particulates in Dhahran, Saudi Arabia," M. Sadiq and AA. Mian, The Arabian Journal for Science and Engineering, Volume 18, Number 2, April 1993. This article describes the chromium and copper concentrations for tk March 1991 - March 1992 period of record (POR). Addition&l chromium and copper [redacted] comparison were made between the 1991 and 1982 metals databases (for total suspended particulate matter). The arithmetic mean PM,, chromium concentrations increased sharply from March 1991 - July 1991, decreased rapidly in August 1991, then gradually decreased through December 1991. These observations are similar to the chromium levels observed by USAEHA PM_{10} sampling equipment at Khobar Towers, Dhahran, Saudi Arabia, for the corresponding POR. In addition, chromium and copper levels were significantly higher in the total suspended samples collected in May and June 1991 than those from the 1982 POR. This paper concluded that the Persian Gulf crisis had elevated chromium and copper concentrations in the ambient air particulates at Dhahran, Saudi Arabia.

Page B-81, 4., Lines 1, 2, 3: Reference should be cited for statement "EPA guidance on BDL."

USAEHA response: Accepted. Reference "EPA, Office of Emergency and Remedial Response, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, OSWER Directive 9285.7-01a, 29 September 1989.

Page B-1-1 through B-1-4: References 3, 13, 14, 15, 16, 20 and 24 are incomplete. References 14, 15, 16 should be USEPA/ORD/AREAL, RTP, NC 27711.

USAEHA response: Accepted. References 14, 15, and 16 have been revised.

Page B-2-12 be in March and April, not February and March.

USAEHA response: Comment is noted.

Page B-2-2 2. Line 10: Should be "TSP concentrations were recorded. ...

USAEHA response: Comment is noted.

Page A-3-16. 2nd Paragraph. last sentence: Change sentence to read "... values range from 3E1 to 3E-2..." (Pyrene has an RfD of 3E-2).

USAEHA response: Accepted, current values as of December 1993 used.

Pages A-3-25 to A-3-28: This discussion of human respiratory tract anatomy/physiology and inhaled particle deposition/fate is extremely simplistic and uses very dated terminology. The newer Casarett and Duoll Text noted above has a better, more current discussion on this subject that might be used - or other recent EPA materials could be used and can be provided upon request.

Also, the discussion on these pages of inhaled particulate matter makes no mention of the possibility or likelihood that inhaled particulate matter may cause lung cancer. Most of the smoke from the oil fires consists of particulate matter. Recent evidence has shown that very high concentrations of carbonaceous particulate matter can induce cancer as well as other forms of lung pathology. There is no discussion of cancer risk due to the inhalation of particulate matter. It may be impossible to quantify such risk; however, there should at least be some discussion.

Also, regarding exposure to PM_{10}, it might be of value to look at the range of exposures rather than mean values, if this is possible. For example, during actual military operations the troops on the front lines may have been exposed to very high dust levels due to movements of tanks, use of explosives, etc. Particle size also makes a large difference. Fine particulate matter (less than 2.5-3.0 micron diameter) is generally considered to pose more risks for noncancer toxic effects and to be much more carcinogenic than larger Particles.

USAEHA response: Comment is noted. An updated discussion of the human respiratory tract has been included in the final report which includes references to potential carcinogenic effects of particulates.

The USAEHA performed limited particulate matter sampling using a dichotomous sampler. In general, the dichotomous samplers developed a high particulate matter loading within hours of sample start time. These samplers were not used after experiencing these problems.

Page B-19 d. Line 16: "CaCl" should be $CaCl_2$

USAEHA response: Accepted response: c o r r e c t e d .

Page B-25, 6th 7th lines from bottom of Page: It seems unusual for the maximum SO_2 concentrations to be 100 to 500 km downwind of the source. Is this in error or is it estimated to occur due to "plume touchdown" at a distance from the emission sources? It would be helpful to discuss earlier (in text concerning monitoring/modeling the updraft transport of fire emission products to atmospheric layers approximately 5,000-10,000 ft. above ground level and dispersion at that height over long distances versus any observed or predicted (modeled) plume touchdown events that would have posed much more risk to humans.

USAEHA response: Noted and is validated by the ground based air sampling. This reviewer is referenced to a series of articles which were published in the Journal of Geophysical Research (Special Section: Studies of Smoke from the 1991 Kuwait Oil Fires, Vol. 97, No. D13, September 20, 1992) which describe the plume transect data collected from fly-throughs by several agencies.

Page B-37, b., Line 6: Did the low volume pump operate at 4.86 L/min. for 24 hours? The maximum flow rate for the Alpha #1 is 5L/min and the maximum for the Dupont 4000 is 4.0umi.n.

USAEHA response: All of the low flow TO13 sample pumps (to include Dupont 4000, Alpha #1, and SKC) operated for approximately 24 hours. The specific sample pump maximum flow rates were accounted for when the samples were wiiected. The low flow TO13 data display appropriate flow rates for the specific sample pumps used.

Were Eglasse fiber filters used for the SSI-PM-10? If so, some SO_2 may have been converted to so, on the filter.

USAEHA response: Glass fiber filters were initially used with the SSI-PM10 samplers. The associated comment is noted.

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Dear Colonel Erdtmann:

As requested in your August 6, 1992, letter, the draft Interim Kuwait Oil Fire Health Risk Assessment report has been reviewed by scientists from the Department of Health and Human Services. As agreed in your subsequent telephone discussion with Dr. Frank Young, Deputy Assistant Secretary for Health/Science & Environment, scientists from the Department of Veterans Affairs, Regional Institute of Standards and Technology, National Oceanic and Atmospheric A[redacted]on, and National Science Foundation also reviewed the document. The names of the reviewers are enclosed. Importantly, some of these personnel were in Kuwait while the oil fires were burning and they experienced, first hand, the oil well fire smoke. Others have extensive experience with models or with evaluating environmental risks.

Several of the reviewers commented on the thoroughness with which the Department of the Army has addressed the issues of veterans exposure to oil well fire smoke. I believe that the Department of the Amy is well on its way to producing an excellent product.

Please let me know if we can be of assistance to you in later drafts of the risk assessment. Specifically, with 6 to 8 weeks of time, a future draft could be sent to these same reviewers and also to the Department of Health and Human Services Committee to Coordinate Environmental Health and Related Programs (CCEHRP). CCEHRP is an inter-agency committee with representation from all of the Public Health Service agencies and the Environmental Protection Agency.

Sincerely yours,
John S. Andrews, Jr., M.D., M.P.H.
Chairman, Kuwait Working Party

Enclosure

USAEHA response: Noted.

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USAEHA response: Noted.

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Mr. will Pendergrass
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USAEHA response: Noted.

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404-488-7320
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USAEHA response: Noted.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Office of the Assistant Secretary for Health
Washington DC 20201

TO: Deputy Assistant Secretary for Health/Science and Environment

FROM: Associate Administrator for Science (E-28), ATSDR

SUBJECT: Comments on "Interim Kuwait Oil Fire Health Risk Assessment"

My comments on the above document are as follows:

General

1, I am impressed with all of the work that the Department of Defense has done in preparing this interim risk assessment. The Department of Defense's willingness to have the document reviewed by persons outside of the Department is commendable. I believe that these outside reviews will result in an even better product.

USAEHA response: Noted.

2. "Data" is a plural word and should be followed by "are" throughout the document.

USAEHA response: Accepted in pt. Current use convention of the word "data" allows the use of a singular or plural verb. This convention is noted in most Webster's dictionaries circa 1984 forward.

3. Exposure information for the time period February 15 - May 4 needs to be added to the risk assessment My observations during the time period March 1-21, 1991, combined with reports from individuals who were in Kuwait during April and May 1991, indicate that there was more smoke at ground level in March than in succeeding months.

USAEHA response: Noted. This is the expressed purpose of the TEAM project. Based upon emissions factor predictions, meteorological data, and with the use of the NOAA HY-SPLIT model in conjunction with a Geographical Information System (GIS), exposures will be modeled for the earlier time period and for various troop units.

4. Information on the number of troops who had extensive exposure (heavy exposure for a long time) to oil well fire smoke would be helpful in assessing the number of individuals who might have various risks of carcinogenic and noncarcinogenic adverse health effects.

USAEHA response: Noted. Again, the TEAM will assist in identifying personnel with extensive exposure.

5. The document needs to add some detail to assure the reader that environmental samples have been taken from areas near to where a majority of the troops have been stationed and that the data can be extrapolated for extensively exposed troops.

USAEHA response: Accepted. A complete discussion of sampling sites and the TEAM model is contained in the final report.

Specific

1. Page 9 - Section V.B.1.a. line 9. "oasis" should be "oases."

USAEHA response: Noted and corrected.

2. Page 23 - All chromium is treated as though it were +6 valence. Some speciation of the chromium would be helpful to get an idea of the relative amount that is hexavalent versus trivalent. Consideration should be given to determining the specific chromium compounds to which the troops were exposed.

USAEHA response: Noted. During a follow-up trip to Saudi Arabia and Kuwait October/ November 1993, the USAEHA sampled both surficial soil and depth profiles to 3 feet to determine the chromium species. Both acid extractable and water soluble analyses were performed. The sampling was accomplished at the same sites sampled in 1991. No Cr^{+6} was identified at any site either in the surficial soils or the depth profiles. Further analysis of particulates captured on PM_{10} samplers during 1991/1993 also indicated no Cr^{+6}.

3. Page 23 - Is benzo(a)pyrene at least as toxic as the other polycyclic aromatic hydrocarbons?

USAEHA response: Noted. Benzo(a)pyrene exhibits the most carcinogenic potential and is at the very least as toxic as the other PAHs.

4. Page 23 - The non-carcinogenic adverse health effects associated with chromium exposure should be discussed.

USAEHA response: Accepted and discussed in the final report.

5. Page 37 - The statement under item 3 agrees with my qualitative assessment. When the smoke was at ground level, Camp Freedom was usually smokier than the U.S. Embassy in Kuwait City.

USAEHA response: d .

6. Page A-2-5 and following - o-, p, and m- probably should be in small letters throughout the document.

USAEHA reswnse: Noted.

7. Page A-3-9 - Suggest further discussion on the non-carcinogenic effects of Chromium since this substances accounts for 99% of the noncarcinogenic risk assessment.

USAEHA response: Accepted. been included in the final report.

8. Page B-16 - Check item b. Benzene and xylene are not heterocyclic compounds.

USAEHA response: Accepted and corrected.

9. Page B-53 - How has the data analysis been handled for Camp Thunderock and Ahmadi Hospital when total suspended particulate sampling was not available for May, June, and July?

USAEHA response: Noted. The USAEHA only collected PM_{10} type samples at the Camp Thunderock and Ahmadi sampling sites. No TSP samples were collected at these sites.

10. Page B-58 and B-61 - These data look like they are not linear. For Khobar Towers, the data seem to show that at 14-18 knots/hr the PM,,, concentration increases greatly. Similarly for Eskan Vii, the windspeed of 8-10 knots/hour the PM,, concentration increases greatly.

USAEHA response: Noted. The USAEHA realizes that the PM,,, concentration versus wind speed plots for Khobar Towers and Riyadh are not linear. We investigated the relationship between these parameters, including wind direction sectors, and found linear correlation coefficients ranged from 0.069 to 0.94. The particulate concentrations remained relatively constant through the 412 miles per hour (mph) wind speed range. Windspeeds above 12 mph displayed varying particulate levels. This reviewer is asked to see additional information on this subject which is contained in the final report.

John S. Andrews, Jr., M.D., M.P.H.

National Institutes of Health
National Institute of
Environmental Health Sciences
Research Triangle Park, N.C. 27709

Memorandum

Date September 24, 1992

From: Assistant to the Director for International Programs

Subject: Interim Kuwait Gil Fire Health Risk Assessment Report

To: Dr. John Andrews, Jr.
Associate Administrator for Science
Agency for Toxic Substances
and Disease Registry

Several NIEHS Staff members and I have scanned the report and offer the following comments:

The models used for predicting health risks are essentially the same systems used for risk assessment of Superfund sites. Based on the results of their models for the air and soil pathway analysis the total predicted excess cancer risk resulting from exposure to the Persian Gulf environment were at least an *order* of magnitude below the EPA range of concern (1 per 10,000 to 1 per 1,000,000). The total predicted non cancer risk (i.e., hazard index) for all pathways and mutes of exposure were 2 to 4 times higher thau the EPA level of concern. The majority of the noncancer risk comes from the inhalation of metals, in particular chromium, which represented 99 % of the risk. We would question how it could be that chromium accounts for a majority of the non carcinogenic risk when it is a known carcinogen. This chromium contamination is believed to be from natural and anthropogenic sources, not from the oil fires.

USAEHA response: Noted. The comment concerning chromium fails to recognize that the metal has toxicity endpoints other than cancer induction. In particular, the noncarcinogenic toxicity endpoint of interest was nasal ulceration.

The monitoring data indicates the environment in the areas of the fires are really not that much different than any oil producing area in other locations throughout the world.

USAEHA response: Noted.

The appendix contains a description of a Biologic Surveillance initiative. The assays to be conducted appear to be adequate to document exposure although the actual cohort sizes are small (e.g., 32 soldiers were used to collect blood for the volatile organics analysis). However, the trace elements assayed (nickel, vanadium [present in Kuwaiti crude oil], lead, cadmium, copper, iron, arsenic, and manganese) did not include chromium which was identified In the models as the major cause of the non-cancer risk. This metal should probably have been looked for.

There is no mention of looking for effects on the reproductive or the immune system. These would be primary areas of concern, especially in light of the recent reports of "oil disease" being cited in Gulf War veterans.

In summary, this could be a very interesting study if the actual size of the cohorts used for the different tests are large enough to provide meaningful data.

USAEHA response: Comments regarding the BSI will be responded to in the BSI report which is to be a separate volume of the total HRA report. We must state that chromium was indeed assayed.

Terri Damstra, Ph.D.
Assistant to the Director
for International Programs

NATIONAL SCIENCE FOUNDATION
Washington, DC 20550
DIVISION OF ATMOSPHERIC SCIENCES
Lower Atmosphere Research Section
Richard S. **Greenfield,** Section **Head**

October 5, 1992

Dr. John S. **Andrews**
Associate Administrator for Science
Agency for Toxic Substances and Disease **Registry**
Public **Health** Service
Washington, DC 20201

Dear Dr. Andrews:

I am **responding** to your letter of September 21, 1992 **requesting Lessons Learned from** Kuwait. **Because** it is easier to use my word p**rocessor** than writing by hand on your form, **I hope that** it will not complicate your task unduly if I respond with this letter.

In response to the **first** question (take-home **messages)** I offer the following: From the viewpoint of the individual who coordinated the US research aircraft data gathering effort, **I** am **left** with a strong sense that we need to be better prepared to respond to environmental emergencies. In particular, we should not impede the response to such emergencies by forcing others to face the most serious frustrations that I had, namely:

a) the expenditure of energy by many **people** to develop **the necessary** funding for **data** gathering efforts through **negotiations** with five **hard-pressed** agencies, without supplemental budgets, during a **period** of high **stress** and short time **schedules, and...**

b) **the expenditure of time and effort by many people to secure the necessary national and international clearances** to move **personnel** and **equipment** into the **area** of **greatest** concern.

In **response** to the **second** question, then, **I** offer the following:

a) Funding mechanisms should **be** established **specifically** for the support of the response **to environmental emergencies.**

b) UN agreements should **be** developed to facilitate necessary national and international clearances for access to regions of environmental emergency.

Finally, I concur with your list of issues. Specifically my response a) to your second question above is addressed nicely by your issue 3.

I hope that this information is useful to you and the PHS. I would appreciate receiving the final list.

USAEHA response: The comments of Mr. Greenfield are noted.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Office of the Secretary
Washington, D.C. 20201

SEP 28 1992

Note to John Andrews:

Subject: Comments on the DOD Report: Kuwait Oil Fire Health Risk Assessment

Suggestions:

1. It would be helpful to include somewhere, in the executive summary or an introduction perhaps, the agencies that reviewed the report. That is, to make it well known that the report has received a wide review and clearance.

USAEHA response: Noted. The response to comments is included in the final. report and includes all the agencies who reviewed the Interim report.

2. The report states on page 1, that other reports from groups conducting monitoring activities did not find significant quantities of pollutants would cause severe health effects. These groups stressed that the long-term health effects on individuals could not be determined because of insufficient data. Therefore, the purpose of this effort is to evaluate the long term effects of the oil fires on personnel. Perhaps it is well understood by some, but it is not clear to me from reading the report what the design specifications will be and what sampling techniques will be employed to collect and analyze the data over the course of the assessment. It might be helpful to lay out the design and methodology to be used more clearly.

USAEHA response: The scope of the study, the design, and the methodology used in this HRA are detailed throughout the final report.

Glen Harelson

DEPARTMENT OF VETERANS AFFAIRS
Veterans Health Services and Research Administration
Washington, DC 20420

OCT 9, 1992

John S. Andrews Jr., M.D., M.P.H.
Associate Administrator for Science
Agency for Toxic Substances and Disease Registry
Atlanta, GA 30333

Dear Dr. Andrews:

To date I have not received any response to the request I made to the Army Environmental Hygiene Agency concerning the application of the equation given on page 17 of the document "Interim Kuwait Oil Fire Health Risk Assessment" to generate intake (mg/kg/day) level and cancer risk. Therefore my comments are without the benefit of their explanation regarding my questions.

USAEHA response: Dr. Kang did receive an indepth answer to his questions in mid-October. The 'Risk Assistant' computer program problem with exposure duration/event was discussed and the calculation corrections were provided such that Dr. Kang could duplicate the intake values found in the report.

I. My general comments on the document are as follows:

1. The Army should be commended for its massive efforts to monitor environmental pollution in or around the large troop installations in the Kuwait Theater of Operations.

2. The document with respect to descriptions of sampling and analysis of air and soil for various petrochemicals and combustion products is very comprehensive and well prepared.

USAEHA response: Above comments are noted.

3. As noted in the document, there is a gap in monitoring data from the onset of oil well fires and the spill in February 1991 to the beginning of the Army monitoring effort in May 1991. By the end of May the majority of the troops were withdrawn from the areas and approximately 15-20% of the oil well fires were extinguished. Furthermore, the 10 fixed ground sampling sites did not correspond to troop movements during the Desert Storm Operation. This may create some potential problems in assessing US troops' exposure to

petrochemicals and combustion products. I strongly encourage the Army to pursue its plan to predict pollutant levels at locations and times when no sampling was made. This modeling effort should be validated against actual measurement data.

USAEHA response: Noted. We share Dr. Kang's concern with being able to predict pollutant levels at locations and times no sampling was accomplished. Again, the TEAM modeling effort is directed at this deficiency.

II. Some specific comments on the document are the following:

1. Air measurement data seems to be consistent with measurements made by other agencies. For example, the Army reported the concentration of benzene at the US Embassy in Kuwait City in June 1991 to be 6.83 $\mu g/m^3$ (Table A-243) or 2.2 ppb (unit conversion made by me). The Interagency Interim Report dated April 3, 1991 reported the concentrations of benzene at the same site to be 0.4 ppb on March 16, 4 ppb on March 17 and 5.2 ppb on March 18, 1991.

USAEHA response: Noted.

2. There appears to be errors in calculating inhalation intake levels (mg/kg/day) using the equation and the parameters provided on page 17. I was not able to duplicate the numbers given in Table A-2-l using the exposure parameters and the equation given in the report. I suggest the authors review the entire table for accuracy of the data presented in the report.

USAEHA response: Accepted. This comment refers to Dr. Kang's opening remark. All calculations have been checked and the tables reviewed due to tie computer error previously discussed.

3. My more substantial concern is the use of EPA's risk assessment methodology to predict the cancer risk for individuals who are exposed to a carcinogen for a short period of time. As I understand it, the slope factor for a specific chemical is calculated based upon the upper bound probability of a cancer response per unit intake of a chemical over a lifetime. Therefore, the estimated cancer risk is applicable only for individuals who are continuously exposed to the chemical for their lifetime. A Dow Chemical study provides evidence that short-term exposure to benzene at low levels can result in an increased risk of leukemia. The average benzene exposure received by the Dow study cohort was 5.5 ppm for 7 years. One leukemia case was exposed only 1.5 years at 1 ppm benzene. (Reference: Bond, G. et al update of mortality among workers exposed to benzene. Br.J. Ind. Med. 43(10) 685-691, 1986.

USAEHA response: Accepted. We agree with Dr. Kang's reservations with the EPA methodology and discussed it as king the most confounding of uncertainties in the interim report. There is no uniform methodology which addresses complex contaminant environs with short term exposures and resultant cancer risk. While it is very appropriate to discuss individual chemical results such as benzene, you in fact are left with a discussion of individual chemicals and their resultant toxicity and nothing more. The current risk assessment paradigms simply have limited application in situations such as the Kuwaiti oil fires. There is however some information which is useful in the current methodology. The calculations are based upon specific exposure periods and the prorated risk calculation result is treated as excess cancers which would be attributable to those exposures. So, while no one is sure that you are dealing with appropriate cancer potency factors, etc. with short term exposures, you can at least compare the excess cancer risk over a lifetime represented by the defined exposures.

4. I believe the method of averaging a short-term exposure level (or intake) over 70 years X 365 days is inappropriate. The EPA risk assessment method is for individuals who are exposed for a lifetime at a given level. The troops were exposed a brief period and it was not appropriate to average their actual intake levels over a lifetime.

USAEHA response: Accepted. As an applied science Agency we use the methods of consensus. It is obvious that there exists a much needed research and development requirement to eliminate the shortcomings of the existing methodologies.

III. Recommendations:

1. The Army should continue to work with NOAA to predict pollutant levels at locations at times no sampling was made.
2. For future use, the Army should organize and archive the measurement data at a central location in a format that is readily accessible to the public.
3. The Army should reevaluate the use of EPA's cancer risk assessment methodology for the US troops who participated in the Desert Storm Operation.

If you or the authors of the document have any questions, I can be reached at (202) 634-4600, FAX (202) 634-4609.

USAEHA response: Noted.

Sincerely yours,
Han K. Kang, Dr. P.H.
Director
Environmental Epidemiology Service

cc: Susan H. Mather, M.D., M.P.H.
ACHD for Environmental Medicine
and Public Health (116)

LESSONS LEARNED FROM KUWAIT

Name Han K. Kane, Dr. P.H. Phone (202) 634-4600
Agency Department of Veterans Affairs FAX (202) 634-4609

1. What do you believe are the important take-home messages regarding environmental public health that have been learned from the U.S. Government's activities in Operation Desert Shield/Desert Storm and the resulting oil spills, pools, and fires in Kuwait and the Gulf?

There appear to be well coordinated US interagency efforts to assess damage to the environment from the Kuwaiti oil well fires and spills, and to monitor immediate acute health care threats. It is also commendable that the US military was active in monitoring air pollutant levels in or around the large troop installations. However, environmental monitoring by the US army did not begin until sometime in May, 1991 when the majority of troops were withdrawn from the areas and approximately 20% of oil well fires were extinguished. The 10 fixed ground sampling sites did not correspond to troop movement during the Desert Storm Operation. This may create some potential problems in assessing US troops' exposure to petrochemicals and smoke.

2. Specifically, what would you do differently next time?

The Army plans to work with the NOAA to predict pollutant levels at locations and times when no sampling was made. This modeling effort should be validated against actual measurement data. For future use, all air monitoring data should be consolidated, organized, and archived at a central location in a format that is readily accessible to the public.

USAEHA response: ted. All data will be archived.

DEPARTMENT OF HEALTH &HUMAN SERVICES
Public **Health** Service
Centers for Disease Control

Memorandum

Date: September 24, 1992

From: Epidemiologist, Air Pollution and Respiratory Health Branch (APRH3)
Health Scientist, Health Studies **Branch (HSB)**
Division of **Environmental Hazards** and Health Effects (EHHE)
National Center for Environmental Health **(NCEH)**

Subject: Comments on Interim Kuwait Oil Fire **Health** Risk Assessment

To: John S. **Andrews** Jr., M.D., M.P.H., **Associate Administrator** for Science, Agency for Toxic **Substances,** and Disease Registry
Through: Director, NCEH
Director, EHHE

General Comments:

We appreciated the opportunity to review the Interim Kuwait Oil **Fire** Health Risk Assessment by **the** U.S. Army **Environmental** Hygiene Agency. The authors of this document are to be **commended** for **assembling** an extensive amount of information in a very thoughtful and comprehensive manner. **The** accompanying appendices provide a thorough description of the methods used to estimate exposures **and an** objective discussion of the potential **health** risks **associated** with the **chemical** components of the oil **fire** plume.

In performing the **quantitative health** risk **assessment,** the authors have applied method5 that had **been** reviewed and approved by the EPA **Office** of **Health** and **Environmental Assessment.** Some **modifications** were **necessary, and the** authors clearly explained the **assumptions used and reasoning behind these assumptions. Risk estimates** were generated for two broad **categories** of **health endpoints, cancer and noncancer.** Atthebegimlitlgofthis **document,** however, the authors should explain that the EPA's methodology for estimating **excess cancer risk provides an upper bound estimate** of excess lifetime **cancer** risk, while the **real** risk may **be** less than that calculated and possibly even **be** zero.

The authors also should explain that neither **EPA** nor anyone else knows how to evaluate **short-term** exposure to chemicals; excess **cancer** risk estimates have teen calculated only for life-time exposures. With cigarette smoking and lung **cancer,** for example, lung cancer rates

for former smokers decline and approach those of nonsmokers after 10 years. Even 10, 20, or more years of smoking do not produce a lung cancer rate among former smokers as high as would be predicted by the methodology used in this interim health risk assessment.

USAEHA response: Noted.

The authors also should discuss the failure of existing risk assessment methodology to address respiratory health risks. This omission of respiratory health risks is especially important in this context bemuse, as stated in the Public Health Service Health Advisory for Kuwait and Saudi Arabia, issued in October 1991, the potential effects on the respiratory system were of particular concern. Although Appendix A-3 included toxicity profiles of several air pollutants and even included a discussion of inhaled particles and human respiratory health, much of this information was not incorporated into the quantitative risk estimates in the main report. As stated on page 40 of the report, "The majority of noncancer risk (at all monitoring sites) comes from inhalation of metals, in particular chromium, which represents over 99 percent of the noncancer risk. However, a reference concentration for chromium has yet to be developed and the reference dose is based on systemic effects other than effects on the respiratory system.

A review of Table A-3-2 in Appendix A-3 reveals that many important air pollutants, including respirable particulate matter, sulfur dioxide, hydrogen sulfide, carbon monoxide and lead were not included in the noncancer risk estimate, presumably because reference concentrations or references doses were not available for these pollutants.

Perhaps the final Kuwait oil fire health risk assessment could attempt to address specifically respiratory health risk, qualitatively if not quantitatively. In addition, the authors should clearly state which of the monitored air pollutants were not included in the risk estimates, and the reasons for their exclusion.

USAEHA response: We commented. In the final report we have attempted to qualitatively address the respiratory health risks from particulates as well as the primary pollutants discussed in your comments.

Specific Comments:

Some of the following comments may be corrected automatically in the final health risk assessment.

Page 4, item 2., first sentence - The document says that CERCLA sites are known as "Superfund." It is the legislation that is known as Superfund and the sites are known as "Superfund sites. . The sentence could be corrected to read..., Compensation, and Liability Act (CERCLA also known as Superfund") sites.

USAEHA response: Accepted and corrected.

Page 7, first sentence - now reads - - contaminant administered of received.. .probably should read -- contaminant administered or received . . .

USAEHA response: Noted.

Page 9, item la., sentence 5 - Is there only one oasis in Saudi Arabia?

USAEHA response: Accepted and corrected.

Page 9 , item la., sentence 8 - Why was the population figure for Kuwait not included?

USAEHA response: Noted. Simple omission. The population figure for Kuwait will be included.

Page 12, first paragraph - Since mention was made of Dhahran in the text, it would be helpful to include its location on the map in Figure 1.

USAEHA response: Accepted and incorporated.

Page 12, item c. - The units for area should be consistent; both square miles and square kilometers in some places.

USAEHA response: Noted.

Page 36 , item 2., next to last sentence - s missing from the word chemical.

USAEHA response: Accepted and corrected.

Page 40, item 4. - If chromium is such a significant part of the inhalation hazard index, and if the source is predominately suspended soil particles, and if the risk evaluation is close to real for the short-term exposure used in this HRA, then the people who spend a lifetime in this environment should show evidence of significant chromium exposure.

USAEHA response: on feral cats exposed to the ambient environment of Kuwait during the oil fire period was recently completed by the Kuwait Institute of Scientific Research. Elevated chromium levels were present in the tissues examined. Our follow-up soils and air study completed in October/November 1993 indicated that the chromium present is not the +6 valence state. Chromium is indeed ubiquitous in the soils of the region.

Page 42, item 4. last sentence, last word - since the background chemicals are the environment and in places this HRA seems to be trying to identify the risk associated with the oil fires then the word environment is inappropriate in this place. What you may be trying to say is that suspended soil chemicals contribute a confounding factor which makes it difficult to identify major sources contributing to the risk from exposure to the specific chemicals incorporated in this HRA associated with working at the locations evaluated.

USAEHA response: Accepted. We are trying to make the point that during the Kuwait oil well fires period there were at least three sources of [redacted]heairmass: the man made pollution otherwise called anthropogenic background; the normal soils constituents; the emissions from the well fires, gushing wells, and the oil lakes. This melange of sources makes it almost impossible to determine the incremental risk associated only with the oil well fires.

Page 44, item El., last sentence - This U.S. locations - something wrong here.

USAEHA response: Accepted and corrected.

Page 44, item A. l., first sentence - This sentence should include a phrase that defines the length of exposure for which these excess life-time cancer risks were calculated, as these values are not valid estimates for 70 years exposure.

USAEHA response: Rejected. As slated your comment is partially correct. The averaging time in the equation for carcinogenic effects equates to a proration of the total cumulative dose over a lifetime (i.e., chronic daily intakes also called lifetime average daily intakes). This approach for carcinogens is based upon the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose received over a lifetime. The exposure duration is defined in the equation as is the averaging time, thus the excess cancer risk values are valid prorated estimates of 70 years exposure.

Mary C. White, SC.D
Mark A. McClanahan, Ph.D.

NIST
UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and technology
Gaithersburg, MD 20899

September 25, 1992

Dr. John Andrews
Associate Administrator for Science (E28)
ATSDR
1600 Clifton Road, NE
Atlanta, *Georgia 30333*

Dear Dr. Andrews:

I am sorry that I do not have the time to provide a complete review of the document entitled "Interim Kuwait Gil Fire Health Risk Assessment", but I do have a few general comments. Overall I am impressed with the scope of the study and how well the document reads. I specialize in smoke research and am impressed by the observation in Appendix G that smoke agglomerates are made up of either large or small primary sizes. I have observed this myself in some large-scale test fires, but this never has been reported in the literature.

USAEHA response: Noted. This observation is a result of the RJ. Lee Group, Inc.'s particle analysis work in support of the HRA.

The health risk assessments are based on measurements at the eight sampling sites. One wonders whether these sites reflect the full range of exposure conditions to our troops and civilians. That is, were there troops stationed in areas where the local concentration might have been significantly grater? While in Kuwait I collected the greyish-white smoke in the ground plume of a combination pool/jet fire and obtained a total PAH concentration of 16 $\mu g/m^3$. It would be interesting to see what this number would correspond to in terms of risk. This would provide a worse case scenario.

USAEHA response: Noted. It is obvious that the static site measurements may not be indicative of the full range of exposure conditions. The TEAM modeling effort is an attempt to quantify the vast array of exposure conditions given the Theater of operations. Your single point source value will be considered in the TEAM effort.

It would be helpful to obtain estimates of the PM-10 particulate that resulted from the oil well fires. This could be done from measurements of the carbonaceous fraction of the particulate, since this would be mainly from the oil well fires. Is such data available? I

would expect that there would be a significant contribution from the fires -as much as several hundred $\mu g/m^3$. There is a problem of reconciling such a result with the statement on page 2 of the executive summary: "In fact, comparing air quality data when the fires were burning with historical data indicates the air quality at ground level at some of the sampling sites was better in 1991 than in previous years for some pollutants." There axe other places where the executive summary seems to present a biased sense that the air really wasn't so bad. For example, it states that the concentration of organic compounds were comparable to levels in Houston and Philadelphia. I think such comparisons are misleading. What is the comparison with a city like Wichita or Washington, D.C.? I would prefer to see statements like "while conditions represented a relatively high level of pollution in terms of - and - , still, because the intense pollution occurred only during specific meteorological conditions and because personnel were typically in the area for a limited time period, the risk in terms of cancer is small.

USAEHA response: d . We are attempting to determine the fractions as stated in the TEAM effort. There are many other parameters to consider if one wishes to perform a carbon balance evaluation of this magnitude, not the least of which is the organic versus inorganic carbon fraction attributable to the fires. There is no bias in the statements concerning the air quality data, the impact of the oil well fires was indeed limited at ground level at our sampling sites due to the 'super plume' effect.

On page A-3-26 of the report, the significance of the aerodynamic diameter in regard to particle deposition in the human respiratory tract is discussed. The standard method of measuring the aerodynamic particle size distribution is with cascade impactors. It is very difficult and labor intensive to obtain accurate information on the aerodynamic size distribution for non-spherical particles from electron microscopy. First there is the statistics problem of sizing a large enough number of particles to obtain an accurate volume distribution and then there is the problem of estimating the densities and shape factors for the particles. More reliable information on the aerodynamic size distribution can be obtained in a few hours of analysis with a cascade impactor than one man year with electron microscopy. It is strongly recommended that information be sought from other groups that might have collected cascade impactor samples. Otherwise the aerodynamic data will be suspect.

USAEHA Response: response to this comment is provided by RJ Lee Group, Inc., 350 Hochberg Road, Monroeville, PA 15146. Telephone number 412/325-1776, FAX 412/733-1799.

RE: Review of Comments Related to Appendix G
RJ Lee Group Project No. GEH309366

I have reviewed Dr. Mulholland's comments regarding the microscopic analysis as presented in Appendix G of the draft document entitled "Interim Kuwait Oil Fire Health Risk Assessment (No. 39-26-L192-91)." I appreciate the interest and concern. However, I believe that the comments are due, in part, to a lack of understanding of the microscopic techniques employed in the study, especially with CCSEM (computer-controlled scanning electron microscopy). This is quite understandable, since the draft report did not discuss the techniques in detail. As you are aware, Volume II of the final report will present detailed summaries of the microscopic analysis. In the meantime, 1 have attempted to address the specific concerns as noted below.

Dr. Mulholland states that "...The standard method of measuring the aerodynamic particle size distribution is with cascade impactors." As Mr. Mulholland correctly points out, most of the size-specific information on source and ambient particles has been based on data obtained from sampling devices designed to fractionate the sample into specific size ranges. Although these samplers have been widely used in environmental studies to obtain information on particle size, they have often been shown to be deficient with respect to accurately determining particle size distribution. For example, the cascade impactor has been shown to have problems with particle bounce.,, Thus, while the cascade impactor is considered aft acceptable technique to determine particle size distribution, it is not immune to problems which may significantly affect the mass distribution.

Dr. Mulholland also states that it is very difficult and labor-intensive to obtain accurate information on aerodynamic size distribution for non-spherical particles from electron microscopy. He states that this is due to ....the statistics problem of sizing a large enough number of particles to obtain an accurate volume distribution and then there is the problem of estimating the densities and shape factors for the particles." While this has historically been true for an analysis performed in a manual fashion, it should be noted that CCSEM was the primary microscopic method used in the analysis of the Kuwait samples. Because CCSEM is capable of analyzing individual particles within several seconds, large numbers of particles can be analyzed in a relatively short period of time, resulting in a database representative of the entire sample. Furthermore computer control of the SEM also enables each particle to be tested against the same set of analysis parameters which assures uniformity of the analysis.[6,7]

The algorithms used in CCSEM to deter— particle size and particle type (chemistry) were developed and previously verified through analysis of standards and comparison with other methods.[8-10] The improved accuracy and reproducibility of CCSEM over manual methods has been demonstrated.[11-13] It should also be noted that CCSEM has been used to determine the particulate removal efficiencies of air and water filtration systems,[14] and evaluate source/receptor relationships.[15] Of potential interest, CCSEM was used to assist the American Iron and Steel Institute (AISI) and the U.S. Environmental Protection Agency (U.S. EPA) in the evaluation of high-volume PM-10 samplers.[16] In summary, based on our experience, we are

confident that CCSEM can provide accurate particle-size data. In fact, it is our opinion that CCSEM has advanced to the point where it is the technique of choice in many fields involving characterization of particulate matter.

Although we feel comfortable with the ability of CCSEM to provide accurate aerodynamic equivalent particle-size information, Dr. Mulholland's comments are well served as they may be typical of scientists not familiar with the technology. Therefore, it should he noted that we have incorporated numerous quality assurance/quality control procedures in the Kuwait study to document our findings including analysis of particle standards, analysis of replicate/ duplicate samples and analysis to evaluate the statistical significance of the number of particles analyzed. These results will be provided in Volume II of the final report. Finally, it should not he overlooked that we have acquired an image of each particle analyzed in the Kuwait study. This documentation can provide insight with regard to particle size. This, in my opinion, may he the best quality assurance aspect of the entire study as it permits a reviewer to "see" the data.

Dr. Mulholland also states that "It would be helpful to obtain estimates of the PM-10 particulate matter that resulted from the oil well fires. This could be done from measurements of the carbonaceous fraction of the particulate since this would be mainly from the oil well fires." We are, in fact, trying to provide this data by sorting the carbon chain agglomerates into its own class rather than in the carbon-rich category. This should provide a very good estimate of the carbon component associated with the oil fires.

Sincerely,

Gary S. Casuccio
Vice President, Environmental Services

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15. T.C. Dzubay and Y. Mamane, "Use of Electron Microscopy Data in Receptor Models for PM-10," Atmospheric Environment, Vol. 23, NO. 2, pp. 467-476, 1989.

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Figure B-6 is misleading, especially to the casual reader of the report who might focus on that part of the presentation. This figure contains a picture of Kuwaiti oil well fires in which the various contributing sources of pollution are identified. The labeling of this figure and text associated with the figure are inaccurate from the standpoint of hydrocarbon combustion in the following ways:

1) BLACK SMOKE (Near Complete Combustion)

Black smoke is the visual indicator of incomplete combustion. Experience in the Kuwait oil fire fields, black smoke emitted from the burning oil pools on the ground was a major contributor to the over smoke all emissions. Measurements made by NIST indicate that pool fires release more than 10% of the oil mass burned as smoke particulate.

RECOMMENDATION: This label be changed to read, "Black Smoke (Incomplete Combustion)." This will also require modifications in the text. In particular, item (3) on page El6 should indicate Carbon or the symbol(C) as a product of incomplete combustion.

2) GREYISH-WHITE SMOKE (Incomplete Combustion)

The "smoke" indicated is condensed volatilized products produced by heating of the oil pools. Although there may be some oxidation of the oil involved in the production of this smoke, the processes that result in condensed hydrocarbons and other products that appear as

greyish-white smoke are best characterized as fuel pyrolysis and not combustion. During our field studies in Kuwait, NIST staff photographed well fires where the downwind trajectory of the black and greyish-white smoke plumes were distinctly separate within 100 meters of the fire, with the black smoke plume rising above the greyish-white plume which remained near ground level. The lack of buoyancy in the greyish-white smoke indicates the absence of combustion.

RECOMMENDATION: This label be changed to read, "Greyish-White Smoke (pyrolysis smoke). " This will also require modifications in the text.

USAEHA response: Accepted and corrected. These comments were most helpful.

I hope that my comments are helpful.

Sincerely,

George W. Mulholland, Head
Smoke Dynamics Research Group

DEPARTMENT OF HEALTH & HUMAN SERVICES

Memorandum

Date: September 25, 1992

From: Chief, Medical Section, SB, DSHEFS, NIOSH (R21)

Subject: Review of "Interim Kuwait Oil Fire Health Risk Assessment"

To: John S. Andrews, Jr., M.D., M.P.H.
Associate Administrator for Science, ATSDR (E28)

I have reviewed the United states Army Environmental Hygiene Agency (USAEHA) document entitled "Interim Kuwait Oil Fire Health Risk Assessment" (No. 39-26-L192-91).

General Comments

There is too much information here for one document. It could easily be presented as three distinct reports: one document describing the results of the environmental monitoring; a second document presenting the risk assessment; and a third document presenting the results of the health study and biologic monitoring done on the 11th Armored Cavalry Regiment.

A thorough editing job will eliminate much of the repetition found in the document.

USAEHA response: final report will be produced in several volumes and will be thoroughly edited.,

Specific comments

Hydrogen sulfide is mentioned as a [redacted]t of concern, but no data are presented regarding the levels of H_2S observed.

USAEHA response: Noted;

Page ES-2, paragraph #6 - states that sampling was initiated when 580 oil well fires were burning. On Page 2, paragraph #1, it notes that 558 oil wells were on fire when environmental monitoring began.

USAEHA response: Accepted. The correct figure is 558.

Page 2 - How many troops were stationed at or in the vicinity of the sampling sites? What proportion of all U.S. troops stationed in the region does this represent?

USAEHA response: Noted. This data is part of the TEAM modeling project.

Page 7 - The rationale for estimating noncarcinogenic effects over the actual exposure period as opposed to a longer period of time should be described. What are the noncarcinogenic health effects of concern?

USAEHA response: Accepted. The rationale is explained in the final report. The noncarcinogenic health effects for the chemicals of concern are found in their respective toxicity profiles.

Pages 45 and B-86 - For some pollutants, lower levels of pollution were measured during the sampling period than in previous years. This is more accurate than saying they were "better."

Accepted. response: n d corrected.

Pages A-2-35 and A-2-43 - An explanation should be offered as to why no volatiles were measured during these periods when they were detected in either the previous and/or subsequent months.

USAEHA response: Noted. The explanation is found in Appendix B.

Page B-34 - hydrogen sulfide is not listed as a contaminant of concern.

USAEHA response: pted. Based on the preliminary work conducted by the EPA in March - April 1991 which did not reveal the existence of high H_2S near the damaged wells or in populated areas downwind of the plume, the USAEHA did not sample for H_2S other than using a real time H_2S monitor during the industrial hygiene sampling.

Page B-45 - Section (i) should indicate that King Khalid Military city was in Saudi Arabia.

USAEHA response: Accepted and corrected.

Appendix D - The description of the industrial hygiene sampling study is incomplete. How was this sampling different from the environmental monitoring? Were personal sampling pumps carried? How many samples were obtained? Were they indoors, outdoors, or both? The types of jobs and duration of sampling need to be specified.

USAEHA response: Noted. The industrial hygiene sampling was conducted outdoors and served as an adjunct to the static site environmental sampling to ensure that we were not missing contaminants of concern. These air samples can only serve as snapshots in time and as examples of potential exposures soldiers may have experienced while maneuvering and fighting near oil well fires.

Appendix F - The results of the biologic surveillance initiative, when available, should be presented separately. I would like to review this section when it is completed.

Page F-8 - What accounts for the different numbers in the pre-, mid-, and post-testing periods?

Page F-9 - The term "capture rates" needs to be defined? I presume it refers to the proportion of soldiers who completed both a pre- and post-deployment test.

Page F-10 - What happened in Doha, August 11, 1991? What records were lost? Capture rates are not presented for spirograms. Is this due to the poor quality of the pre-deployment pulmonary function tests?

These data will be an important contribution to our knowledge regarding health effects of service in Kuwait and Saudi Arabia during Desert Shield/Storm and its aftermath. The authors should be commended for their efforts. I would be pleased to review any subsequent revisions. Thanks.

USAEHA response: All comments regarding the BSI will be addressed in the separate BSI report volume.

Paul J. Seligman, M.D., M.P.H.

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
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TO: Dr. John Andrews

FROM: Lisa C. Symoas
Regional Liaison

Date: October 1, 1992
FaxPhone: 404-639-0586
Voice Phone:

Total #Pages: 1

Comments on the Kuwait Risk Assessment Document by USAEHA.

If this is the interim assessment is there to be another interim document that will include the September - December 1991 data analysis? The text stated that the final document would include this information, although it appears there wouldn't be a peer review of this information.

USAEHA response: Noted. The final report does include the data analyses in question. It is anticipated that the report will be peer reviewed.

Clarification on how the NOAA air model back trajectory will be used for assessing doses to US military and civilians in area where direct monitoring did not occur. This procedure was mentioned in several instances, how accurate will this be? (Comments from Bruce Hicks)

USAEHA response: currently using the NOAA HY-SPLIT modeled data in a geographical information system (GIS) to assist in completion of the final comprehensive Kuwait oil well fire health risk assessment. The HY-SPLIT modeled data is part of the GIS database which includes satellite data, troop unit movement data, and USAEHA ground based air sampling data. The USAEHA has received a detailed write-up from NOAA/ARL which describes the performance of the HY-SPLIT data. The *reviewer is* referenced to the final report which contains a detailed explanation of the GIS aspects of the health risk assessment.

Further discussion on the cumulative effects of the pathways for specific compounds, would be appropriate if such information exists. Do EPA health standards approach the issue from a one pathway perspective, or do they include multiple means of impact to the individual.

USAEHA response: Noted. Estimating risk or hazard potential by considering one chemical at a time may considerably underestimate the risks associated with simultaneous exposure to multiple chemicals. The EPA (1986b) has developed *Guidelines* for *the Health Risk Assessment* of *Chemical Mixtures* that can also be used in the case of simultaneous exposure to several chemicals, from several sources, through multiple pathways. The calculation methods are somewhat different than the classical carcinogenic/noncarcinogenic effects formulas but both procedures assume additivity of dose in the absence of mixture specific information. The health standards (e.g., health advisories) generally are chemical-specific unless defmitive studies indicate antagonism, synergism, etc.

Has information from this study incorporated or used any of the materials from the Kuwait Data Archive project to cross compare results, particularly on plume content analysis? The archive project, has data and analysis from most of the research projects that assessed the oil fires. Will the data from this project be included in the archive, if not how accessible will it be to other researchers?

USAEHA response: The USAEHA is aware of the KUDA and has imported satellite data from this database. We are currently unable to provide *our data to the* KUDA database due to its nature in assessing the exposure to troops potentially exposed to the Kuwait oil well fires. The data used in both the HRA and the TEAM modeling project will be archived and will be available to other researchers.

National RESEARCH COUNCIL
BOARD ON ENVIRONMENTAL STUDIES AND TOXICOLOGY
2101 Constitution Avenue Washington, D.C. 20418
October 9.1992

Col. Frederick J. Erdtmann, Medical Corps
Department of the Army
5109 Leesburg Pike
Falls Church, Vii 22041-3258

Dear Col. Erdtmann:

This is in response to your letter of August 6, 1992, in which you requested that we provide peer review of the report "Interim Kuwait Oil Fire Health Risk Assessment, No. 39-26-6192," that was prepared by the U.S. Army Environmental Hygiene Agency. Several members of the National Research Council's Committee on Toxicology (COT) have reviewed the report and provided their initial comments. This letter constitutes a summary of their more important remarks. COT has not conducted a formal review of this report nor has the committee held any formal discussion of the report or the reviews by individual members; therefore, these are comments from individuals and do not represent the views of the National Academy of Sciences.

USAEHA response: Noted.

The reviewers found the report straightforward and easy to read. As indicated in the report itself, it is not yet complete. The reviewers noted some of the omissions. One of the reviewers, commenting on the Biologic Surveillance Initiative (BSI) remark&

"These data will provide some useful biologic indices of exposures among military personnel in the Gulf... exposed to various emissions from the Kuwaiti oil fires. As such, the BSI provides information that complements the environmental exposure measurements.. . . However, . . . I have three major concerns with the BSI.

1. The health effects data are limited and may be inadequate to deal with the range of problems that might be expected. The data collected are unlikely to consider adequately more subtle and important issues such as neurobehavioral effects.

2. The focus of the BSI is...on absorbed (systemic) dose. This is inadequate...for respiratory and dermal problems. The.. goals of validating environmental exposure estimates from biological indices, and using biological indices to model exposure-response relationships may be achieved to far less degree than anticipated by the investigators.

3. The number of subjects undergoing more than a basic questionnaire and spirometry is small. Low statistical power will be a problem...The opportunity to model exposure-response relationships with these data will be very limited...This will be a major weakness...unless very large health effects are present."

USAEHA response: All comments referring to the BSI will be addressed in the BSI report volume.

Two reviewers raised concerns about specific toxic effects. In particular, one wrote, "Apparent omissions from these models are the direct toxic effects of agents on the skin and respiratory tract...The plan (apparently) places the focus on absorbed dose, which is probably not of primary relevance to the development of skin and respiratory problems. I am particularly concerned about the apparent omission of direct dermal toxicity given the recent reports of...symptoms and illnesses...[the chief complaints...[being] skin lesions]." This reviewer was also concerned about the contamination of clothing and how this might facilitate exposures. *He* remarked further, that "the emphasis on soil contamination might seriously under&mate dermal contact and exposure via clothing.

USAEHA response: Noted. We agree with the commenter's remarks. The current EPA risk assessment paradigm does not account for direct toxicity. For the respiratory issue we have added qualitative discussions of risk in the final report. Although a number of the compounds of concern exhibit toxic effects to the skin (primary irritation), these effects typically occur at much higher concentrations than found in environmental exposures. For this reason, we focused on the systemic effects of the contaminants. The expressed concern of compound-related effects on the respiratory system is handled somewhat by using the RfC values in evaluating non-cancer inhalation risks which presumably addresses the most sensitive toxic endpoint by this pathway.

The other reviewer concerned with possible underestimates of specific exposures noted that "one potential shortcoming...related to the...polycyclic aromatic hydrocarbons (PAH's), and their adsorption on respirable particulate matter (PM_{10})." This reviewer remarked that because "...these PAHs have relatively low vapor pressures and will quickly condense on the surface of respirable particles, the risk associated with exposure to PAHs may have been underestimated."

USAEHA response: Noted. We coupled both standard chemistry analyses with CCSEM, TEM, and other modalities in an effort to minimize this possibility.

The time-span over which measurements were made was also commented on. "[A]ir pollutant measurements were not made before May 1991...[prior to which] some of the oil fires were put out." *The reviewer finds this to be* a serious concern because the atmosphere

modeling was not predictive during the period in which measurements were made. This reviewer, examining figures B-5-1 through B-5-12 noted a "spike" in the PM_{10} concentrations at all the sampling locations - and questions whether this spike is correlated "with some significant atmospheric and/or geothermal event."

USAEHA response: The USAEHA was not abie to enter Saudi Arabia and Kuwait until 4 May 1991. For the February - April 1991 time period in which the USAEHA has no ground level air monitoring data, we have coordinated with the National Oceanic and Atmospheric Administration, Air Resources Laboratory (NOAA/ARL) in providing modeled ground level air concentrations for the Kuwait Theater of Operations (KTO). This NOAA/ ARL modeling effort is for the February-October 1991 period of record. The modeled data is being used for the final comprehensive Kuwait oil well fire health risk assessment using a geographical information system (GIS). The GIS will integrate all pertinent databases to include modeled air concentration data, USAEHA ground level based air concentration data, satellite imagery, and trwp unit movement data in order to determine the exposure of DOD military and civilian personnel from the Kuwait oil well fires while they were in the KTO. Additional GIS information is found in Annex B-7 of the final health risk assessment report.

This reviewer's examination of the report is summarized as demonstrating two areas of uncertainty in which there may be a potential for increased risk:

1. Lack of measurement of the PAHs on the surface of respirable particles

2. Lack of samples prior to May 199 1

Of further concern is that the environmental measurements do not seem to be related to the proximity to the burning wells (one would have expected greater evidence of contamination nearer the fires) and there appears to be no time trend correlating (decreasing) exposure levels with decreasing number of burning wells. Are there any measures correlated with time and place which are not described in the report?

USAEHA response: The USAEHA performed ground based ambient air sampling at major staging locations for DOD military and civilian personnel. Limited ambient air sampling was conducted at the Al Ahmadi hospital, located in the Al Ahmadi oil field area. There were elevated levels of volatile organic compounds, and at times particulate matter at this sampling location. The final health risk assessment report contains more information on any possible correlations of pollutant levels versus time and in relation to the extinguishment of the oil well fires. An important note is the ambient air samples collected in Kuwait and Saudi Arabia during the May-December 1991 are a composite of all air emissions sources to include the oil well fire emissions and anthropogenic emissions.

Some specific technical issues were also raised by several of the reviewers:

Inhalation Exposure

1. One reviewer expressed great concern that the dose-response model which appears to assume Haber's Law (i.e., risk is directly proportional to concentration x time), which he observes "...does not hold for many compounds over such a range of exposure times.

USAEHA response: Noted. The risk assessment methodology used is that defined in the EPA document Risk Assessment Guidance for Superfund, Volume 1 Human Health Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002, December 1989. In chapters 7 & 8 of this document rationales for computation of carcinogenic and noncarcinogenic risk can be found. The EPA guidelines recommend the use of the linearized multistage model which generally predicts the most conservative cancer potency for a compound. Then the upper 95th percent confidence limit of the slope of the dose-response curve is calculated to produce the slope factor. The slope factor thus represents an upper 95th percent confidence limit on the probability of a response per unit intake of a chemical over a lifetime (i.e., slope factor = risk per unit dose = risk per mg/kg-day) or essentially Haber's Law. A further conservative step in this procedure is the development of the reasonable maximum exposure (RME). The RME is the selection of the intake variables such that their combination results in an estimate of the maximum exposure anticipated to occur for the selected exposure pathway. The exposure concentration values used in development of the RME should be based upon the 95 percent upper confidence limit on the arithmetic average of measured concentrations for a given compound. All compound RME's calculated within a given pathway of exposure are then summed to provide a total pathway risk. All pathways of exposure are then summed to provide total carcinogenic risk.

2. Some of the measures entering the equations on pages 17-19 were questioned. Basically, it is not clear how exposure was &mated.

USAEHA response: Noted. All equations and default values are defined in the final report. Sources and or rationale for using selected values are identified with the individual equation..

a "...the unit conversions factor, CF, in the equation for calculating intake by inhalation (p.17) is unnecessary because the contaminant concentration in air is given in mg/m^3. Inclusion of this factor reduces estimated intake rate by a factor of 1,000." [Note: In the data presented in Tables A-2-l through A-2-52, the concentration is given in $\mu g/m^3$. If this was uniformly true, then the conversion factor of 10-3 is appropriate to convert to mg/m^3, as given in the equations. This needs to be clarified.]

USAEHA response: Accepted and clarified.

b. "It appears that the exposure duration factor (ED) in equation 1, p. 17 introduces an over-adjustment. Already only 30 days exposure frequency is counted in the exposure duration factor (EF). Either EF=30 days, and you don't need ED at all, or EF=30 days per year and ED = 1 year. You are already dividing by AT (365 days/year x 70 years) to adjust the 30 days exposure to a lifetime daily exposure. Note that in line 2 on p. 19, the LADD is calculated by adjusting the ADD by the factor (exposure period in years/lifetime in years). This factor in the present case is 0.083/70 = 30/(365 x 70) - Thus the factor 0.083 = 30/365 is used only once, not twice." Similar questions arise about the ingestion exposure and the dermal exposure. The reviewer's comments are given below:

USAEHA response: Accepted and corrected.

"Ingestion exposure"

In equation (2) on page 18, the factor IR is expressed in mg/day, whereas the factor EF is in events/year. Unless 'day' and 'event' are interchangeable, the calculation will not result in the indicated units of mg/kg-day.

USAEHA response: Noted. Day and event are interchangeable.

The same questions raised above regarding the ED factor for inhalation exposure applied also to the calculation of ingestion intake.

USAEHA response: Noted.

"Dermal exposure"

The dermal intake equation on page 18 includes two different values for surface area (SA). Where is each used in this risk assessment?

USAEHA response: Noted. The 3460 cm^2 was the skin surface area defined as being available for contact during work exposures. The 7510 cm^2 was the skin surface area defined as being available for contact during recreational exposures. The dermal route of exposure risks have been calculated and are included in the final report. This route of exposure was not evaluated in the interim report due to lack of EPA guidance in dermal risk assessment.

For the dose units to come out right, the skin adherence factor apparently needs to be in units of mg soil/cm^2 surface area/event. Otherwise the 'event' unit won't cancel in the calculation of absorbed dose.

USAEHA response: Noted.

The same question raised above for inhalation and ingestion exposure regarding the ED factor applies also to dermal exposure.

USAEHA response: Noted. Event and day are interchangeable.

Is there a possibility of dermal exposure from air contamination? If so, this needs to be included. If not, there ought to be a statement to that effect."

Accepted and discussed in the final report.

Finally, some issues are raised concerning the use of the hazard index (HI). One reviewer remarks, "It is not logical to sum hazards indices for chemicals that do not act through similar mechanisms, and I do not recommend it."

USAEHA response: Accepted. Please note that regardless of how you sum the HIs that only one compound is responsible for exceeding unity.

Another reviewer notes:

Hazard indices (HI) between 2 and 4 were calculated for all sites. It is not clear how much concern there ought to be about those numbers, but the discussion in the document tends to downplay their significance. That might be defensible, provided the present exposure estimates are reexamined and found not to include an overadjustment for exposure duration. But if exposure estimates were to increase by 10-fold or more upon recalculation, then both noncancer and cancer risks might become of concern, even if the primary source of contamination is not oil fires.

USAEHA Accepted.e: The correction of the exposure intake formulas did not result in an order of magnitude change in either carcinogenic or noncarcinogenic risk estimated

A ge—lized set of conclusion/questions arise out of the comments of the reviewers:

1. The report seems to be clear and well presented. The overall approach appears to be sound.

2. Some questions exist as to whether exposures measurers are appropriate, and complete, and cover a broad enough period of time.

3. Technical issues have been raised about the appropriateness of "conversion factors" and the meanings of some terms used in the exposure equations - such as "events."

4. The appropriateness of the Habers Law type approach over a wide range of exposure times is questioned.

5. The follow-up studies proposed are likely to have low statistical power, and a sound scientific basis for the studies needs to be developed before they are initiated.

It is my understanding that there is a thorough review planned of the scientific, medical and other information on the health consequences of military service in the Persian Gulf Theater of operations during the Persian Gulf War. We look forward to working with you on this review.

USAEHA response: Noted. The summary comments were addressed in previous responses.

Should you have any questions, please feel free to contact me at (202) 334-2616.

Sincerely,

Richard D. Thomas, Ph.D., D.A.B.T.
Director, Human Toxicology
Risk Assessment

DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
WASHINGTON, D.C. 20372-5120
IN REPLY REFER TO
6200
Ser 24B/2U785642
23 Sep 92

From: Chief, Bureau of Medicine and Surgery
To: Colonel Richard Erdtmann, USA, MC, Chairman, Kuwait Oil Fire Health Effects Working Group

Subj: INTERIM KUWAIT OIL FIRE HEALTH RISK ASSESSMENT

Ref: (a) Kuwait Oil Fire Health Effects Working Group mtg of

30 Jun 92

Encl: (1) NAVENVIRHLTHCEN ltr 6200 Ser 64/5146 of 11 Sep 92

1. Per reference (a), enclosure (1) is forwarded for your review.

2. My point of contact is Lieutenant Commander Robert Beardall, MC, USN, Assistant Director, Preventive Medicine and Occupational Health Division (MED-24B), at (202) 653-1788.

HUGH P. SCOTT
Assistant Chief, Operational
Medicine and Fleet Support

USAEHA response: Letter of transmittal is noted.

DEPARTMENT OF THE NAVY
NAVY ENVIRONMENTAL HEALTH CENTER
2510 WALMER AVENUE
NORFOLK, VIRGINIA 235 13-2617

SEP 111992

From: Commanding Officer, Navy Environmental Health Center
To: Chief, Bureau of Medicine and Surgery

Subj: INTERIM KUWAIT OIL FIRE HEALTH RISK ASSESSMENT

Ref: (a) BUMED ltr 6200 Ser 242/2U785284 of 8 Jul 92

Encl: (1) MEDICAL REVIEW OF INTERIM KUWAIT OIL FIRE HEALTH RISK ASSESSMENT

1. Per reference (a), medical review of the document entitled "Interim Kuwait Oil Fire Health Risk Assessment, No. 39-26-L19291, 5 May - 15 September 1991" has been completed.

2. We focused on determining whether the methodology used was appropriate and on determining whether there is strength of association between the data analysis and the assessment of health risk. To summarize:

a. The methodology used was appropriate, in so far as the general procedures and basic equations defined in EPA guidance documents have been utilized. However, atypical methodology was used to derive exposure duration and averaging time parameters.

b. This investigation differs appreciably from the types of investigations performed under the Navy Installation Restoration Program (IRP). This is significant in the context that not all steps or requirements of a remedial investigation, as defined under the IRP, have been met. The differences do not necessarily diminish the validity of the derived risk estimates; however, certain assumptions have not been defended or documented to the extent that would be required of IRP contractors.

c. Generally good strength of association exists between the data analysis and the assessment of health risk; i.e., the data summaries presented appear to be appropriate and the risk estimates were calculated with the aid of an EPA-approved computer modeling program.

3. The validity of the derived risk estimates can be challenged on several premises: sufficient data is not presented with the report to allow conclusive judgment on whether the data summaries presented are accurate; certain assumptions which are incorporated into calculations of risk have not been adequately defended and/or documented; the contribution to health risk associated with inhalation of particulate matter does not appear to have been adequately addressed. The comments provided in enclosure (1) expand on these issues.

4. In view of the concerns stated above, the report's conclusion of "insignificant health risk" should not be viewed as an unequivocal determination. Although this report describes au investigation which required prodigious effort, the conclusions presented by the Army Environmental Hygiene Agency may not be uncontested.

5. My point of contact for this review is Ms. Andrea Lunsford, Head, Health Risk Assessment Department, who may be reached at (804) 444-7575 or DSN 564-7575, extension 402.

USAEHA response: The summary comments are noted. Detailed responses are provided along with the Navy's enclosed specific comments.

w. P. THOMAS
By direction

Final Rpt, Kuwait Oil Fire HRA No. 39-26-L192-91, 5 May - 3 Dec 91

MEDICAL REVIEW OF
INTERIM KUWAIT OIL FIRE HEALTH RISK ASSESSMENT

General Comments:

1. The draft document entitled "Interim Kuwait Oil Fire Health Risk Assessment, No. 39-26-L192-91, 5 May - 15 September 1991" was provided to Navy Environmental Health Center for review on 20 July 1992. The report was prepared by the United states Army Environmental Hygiene Agency.

USAEHA response: Noted.

2. Our assessment is that the methodology used was generally appropriate and that good, strength of association exists between the data analysis and the assessment of health risk; however, the report provides insufficient data and information to allow conclusive judgement. For example, while the data summaries presented appear to be appropriate, some of the "raw data" tables are not included with the report, thus the validity of the summaries (which present only derived values) cannot be established. Likewise, although the risk estimates appear to be calculated correctly, sufficient information is not provided about the basic assumptions which have been incorporated in the risk calculations. The validity of the derived risk estimates could therefore be challenged.

USAEHA response: Noted. A separate volume containing all data sets will be produced. We hope this will assist you in your determination of validity of the health risk assessment.

3, The specific review comments provided below primarily address the gaps in information which preclude conclusive judgment on the strength of association between data, analysis, and conclusions. Several comments have been included which address the few discrepancies we noted in the methodology. We have presented these comments and recommendations in the format we generally use for remedial investigation reviews, i.e., the comments are tied to the specific location in the text where the information is introduced.

USAEHA response: Noted.

4. The technical point of contact for this review of the Interim Health Assessment is Ms. Andrea Lunsford, Head, Health Risk Assessment Department, Environmental Programs Directorate, Navy Environmental Health Center, who may be contacted at (804) 444-7575 or DSN 564-7575, extension 402.

Specific Review Comments:

1. **Page** 3, Section IV (General), subsection B (Project **Scope), subsection 3** (Biologic Surveillance).

Comment: This **paragraph** briefly **describes** the biological **surveillance initiative (BSI)** that was conducted as a **separate** phase of the project. The last sentence of the **paragraph** states that "This **comparison** [between the **BSI** results and the **estimates** projected by this health risk assessment **(HRA) "Will** either lend validity to the **HRA** or show that its predictions are too **conservative** or not conservative enough."

Although there is no question that the BSI will provide **valuable** information, it is not obvious that comparison of results (i.e., **comparison** of the risk **estimates** provided **in** this report to **the BSI results) can be expected to support or refute the validity of the health risk estimates. The degree to which the BSI results will support or refute the validity of the risk estimates is dependent** on a number of variables such as the length of the **period** of biological surveillance, the type of biological samples that will **be** collected, the type of analyses that will be, conducted on the biological samples, and if **causal** relationships between contaminants of concern and any **biological** effects noted have been **pre-established.** This is especially true for carcinogenic **effects,** since long latency periods **are** associated with many types of cancer. It is also apparent that prolonged monitoring periods would be required to establish **statistically significant** increased morbidity values.

For the reasons stated above, a **categorical** statement that the BSI will either lend validity or diminish validity should not **be** made. Rather, some statement relaying the fact **that** many **parameters** may determine the usefulness of the BSI results should be included.'

While only a cursory **description** of the BSI is included in this "report section," Appendix **F provides** a more **detailed description.** Likewise, while only this single statement about the **applicability of the BSI results is made in this section, an expanded discussion is provided in Appendix** F and includes some **caveats about** the significance of the **BSI** results.

USAEHA response: **Noted. Responses to comments concerning** the BSI will be provided **in** the BSI report volume.

2. Pages 9 to 21, Section **V (Health** Risk **Assessment),** subsections B, C, and D (Exposure Assessment, Toxicity Assessment, and Risk Characterization).

Comment: In subsections B, C and D statements are made which assert that the **health** risk assessment was conducted "according to EPA approved protocols"; i.e., that exposure **parameters** were calculated with the **appropriate** equations (pages 16 through 18); **approved**

"health effects criteria" were used (page 20), and that correct methodology was used to calculate quantitative estimates of carcinogenic and noncarcinogenic health risk (page 21). After reviewing the equations and other information presented we conclude that:

a. The equations used to quantitate exposure parameters are indeed those recommended and defined in the referenced EPA guidance documents.

b. The appropriate "health effects criteria" have been used to derive risk estimates; i.e., chemical-specific "reference doses" (RfDs) and "carcinogenic slope factors" (CSFs), as defined by the EPA, have been used. Some of the individual RfDs used do not appear to be correct; this is addressed in a later comment.

c. It can be safely assumed that appropriate equations were used to quantitate risk, since the "Risk Assistant Computer Model" is a commercially available computer software program that was developed in conjunction with the EPA, The "Risk Assistant" program contains all the appropriate risk equations.

d. Although "Risk-&s&ant" contains all the appropriate risk equations, the user must input certain values which are not known until the investigation is conducted (e.g., exposure frequency (EF), averaging time (AT), etc). Some of the input parameters used have been generically stated in this report; for example; where the equations for "intakes" are given on pages 17 and 18 the definitions provided under each equation states that an AT of "70 yr X 365 days/yr" (or 25,550 days) was used. Elsewhere in the report it is noted that this specific AT may not have been used. It would be beneficial if the input parameters were documented in the appendix for each exposure scenario and risk calculation.

USAEHA response: Comments 2a-c noted. Comment 2d accepted. AU input parameters have been defined in the final report.

3. Page 16, Section V (Health Risk Assessment), subsection B (Exposure Assessment), paragraph 3.b. ("Sample Data").

This short paragraph contains statements that have significant implications to the perceived validity of the risk estimates derived in this assessment. The first of these appears in the first sentence, which states that "Table 1 lists the environmental media considered in this analysis (out of a possible set of ground water, surface water, air, soil, sediment, crops, and biota). "The media listed in Table 1 are "Air" and "Soil"; this raises the question of why other media were not considered, since an explanation for excluding them is not provided,

a. There are numerous "possible" reasons for excluding media from consideration in an environmental investigation, for example: the scope of work/data quality objectives for this phase of the investigation did not include sampling media other than air and soils (perhaps a resource issue); samples were collected from other media, but widely variant contamination levels were detected in those media, so it was considered prudent to exclude them (perhaps a quality assurance issue); other media were sampled but time constraints precluded analysis of these data (an efficiency issue); etc. The stringent protocols established for remedial investigations (RIs) conducted under the Installation Restoration Program (IRP) would require that all potential media pathways @round water, surface water, air, soil, sediment, biota) be considered, then eliminated on the basis of demonstrating that it would be unlikely for those media to be contaminated or, if they are potentially contaminated, unlikely that humans would be exposed to them. Generally, statements about the physical character of the site, about the physical transport mechanisms involved, and about human use patterns are invoked to justify exclusion. In this respect, this "situational" risk assessment differs appreciably from the generally accepted standard for RIs.

b. It is important to note that while the Army Environmental Hygiene Agency (AEHA) has electedtousetherisk assessment methodology EPA developed for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites, they have also elected to adopt a much-simplified format for reporting/documenting the investigation and findings, at least in this interim 'report. In our opinion this is entirely appropriate, given the intended audience and the fact that the purpose of the risk assessment is not to develop a remedial strategy. However, it should be pointed out that reviewers familiar with RI requirements might view this as inadequate documentation for elimination of potential exposure pathways. For example, the elimination of ground water as a potential exposure pathway could be viewed as underestimating the potential risk, since the volatile organic compounds associated with petroleum products are often transported to ground water, and the ground water pathway (through an ingestion scenario) almost always presents the highest potential risk associated with CERCLA sites. Elimination of the ground water pathway could be justified if personnel stationed in the area did not use ground water as a potable water source, but this justification should be clearly presented in the report.

USAEHA response: Accepted. Discussion of pathway selection/elimination is included in the final report.

4. Page 16 , Section V (Health Risk Assessment), subsection B (Exposure Assessment), paragraph 3.b. ("Sample Data") and Table 1 ("Environmental Media Evaluation").

Comments: The second sentence in this paragraph states that "This table [Table 1] also indicates the technique used to wmbii data from multiple samples in each medium and the sample set that was included." It would be difficult to overstate how significant the information presented in Table 1 thus becomes, particularly in view of the fact that "raw data" tables of the air sampling results are not provided.

a. Whereas the accepted standard for RIS is to present "raw data" tables (generally in appendices) for comparative purposes, this investigation report requires a "leap of faith" that data has been combined correctly into representative data sets. Reviewers must accept, without the benefit of demonstration, that any exclusions of sampling results were indeed appropriate; that the number of exclusions were insignificant relatively to the number of inclusions; that the "mean concentrations" and upper 95 percent confidence intervals of the mean (95 % UCL) values were calculated correctly; and that the number of "nondetects," for which substitute values have been included, are not so great as to skew the data set. The "Aggregation strategy" column in Table 1 states only that sample means and 95% UCLs were calculated for the data sets.

b. There is ample reason for not including "raw data" tables of the air sampling results in this report; on page 45 (paragraph B, "Air Pathway Analysis") it is stated that "Nearly 4000 air samples were collected during this period from 10 fixed ground-based sampling locations." The sheer volume of sampling results precludes inclusion. Nonetheless, it must be pointed out that many discrepancies found in health risk assessments can be traced to the data reduction/data grouping stage. Since this aspect of the data analysis cannot be reviewed, a conclusive judgment cannot be made about the validity of the risk estimates that will subsequently be based on the means and 95% UCL values derived in this stage of analysis.

c. "Frequency of detection" statistics are often included in traditional RI reports. These statistics relay valuable information about the number of samples within a given data set that contribute to the risk and the number of samples which may effectively "ameliorate" the risk. Frequency of detection statistics have not been presented in this report.

d. The data could have been better evaluated if the report included a representative subset of air sampling data to demonstrate, if only on "an example" basis, that excluded data were appropriately excluded; that the number of exclusions were insignificant relative to the number of inclusions; that the mean wncentrations and 95 % UCL values were calculated correctly; and that the number of "non-detects" were not so great as to skew the data set.

USAEHA response: Accepted. A complete volume of the final report is dedicated to data, QA/QC, etc. In addition, validated data sets are provided throughout the health risk assessment volume to assist the reader in a determination of whether or not appropriate methodology was used. 4

5. Page 16, Section V (Health Risk Assessment), subsection B (Exposure Assessment), paragraph 3.b. ("Sample Data") and Table 1 ("Environmental Media Evaluation").

Comments: The text refers to Table 1 and states that "The final column indicates the approach used to assign concentrations when a chemical was not detected in some of the samples. "

a. This is an ambiguous statement, since it does not clarify whether the stated approach was always used or used only for specific chemicals and/or specific analytical methods; since various types of analyses were performed, the table should indicate whether "1/2 of the detection limit" was used to adjust non-detect values in all analyses or only some. Table 1 seems to indicate that "1/2 the detection limit" was substituted in all analyses. The analytes included on Table 1 for air sample analyses are: PM_{10}, volatiles, metals, PAHs, and nontarget analytes, since the PM_{10} measurement is a gravimetric procedure, it is not likely that "1/2 of the detection limit" was used for the PM_{10} sample sets.

b. Table 1 indicates "1/2 of the detection limit" was used in the treatment of non-detects; this does not provide adequate description of the substitute values used. There are two types of commonly used detection limits: "instrument detection limits (IDLS) and "method detection limits" (MDLs). Method detection limits will almost always be somewhat higher values than IDLs; this is because manufacturers develop IDLs under ideal laboratory conditions, in order to show, in instrument specifications brochures, that their instruments are indeed very sensitive (e.g., have very low detection limits). Method detection limits are higher, because ml-world laboratory analyses can be subject to interferences related to the method itself.

"Sample quantitation limits" (SQLs) are different values than either IDLS or MDLS. SQLS are almost always higher than MDLs. This is because SQLS account for sample characteristics, sample preparation, or analytical adjustments that differ from sample to sample. Sample quantitation limits also account for the fact that "detection" is not equal to "quantitation." A chemical may be detected, but detected at a value so close to "baseline detection" as to be unquantifiably greater than the method detection limit.

c. The EPA guidance document "Risk Assessment Guidance for Superfund" (BAGS Manual) directs the use of "one-half of the sample quantitation limit (SQL)" as a proxy concentration for "non-detects" if there is reason to believe that the chemical is present in a sample at a

concentration below the SQL. (The SQL value itself can be used if there is reason to believe the concentration is closer to it than to one-half the SQL.) The guidance also is clear in stating that method and/or instrument detection limits (MDLS or IDLS) "should rarely be used for non-detected chemicals" since it is a measure only of the detection limit for a particular method or instrument, respectively, and does not consider the effect of sample handling and preparation or sample characteristics.

d. Since SQLS are higher values than either MDLs or IDLs, the value "SQL/2" is a greater value than "MDL/2"; similarly, an "MDL/2" value is a greater value than "IDL/2." This being the case, the use of "1/2 the detection limit" for substitute values leads to an "under conservative" final risk value, relative to EPA requirements for CERCLA sites.

e. In Appendix C ("Soil Sampling and Soil Pathway Analysis"), Tables C-2 and C-3 present analytical data in a column entitled "Limit or Quantitation (μg/kg)." However, no statement is given in the text to clarify whether these are sample quantitation limits or method detection limits. It is assumed that these are method detection limits, since sample quantitation limits may vary from sample batch to sample batch, and one column description, per type of analysis, could not provide them. There is also no statement in the text as to the use of these "quantitation" limits with respect to the treatment of non-detects. Requirements for RI investigations conducted under the IRP include evidence that the analytical laboratory has provided sample quantitation limits for each analysis performed, these SQLs provide the basis for data validation qualifiers to be attached to sample results.

USAEHA response: Accepted. The data tables have been appropriately annotated in the final report. A complete description of how non-detects were handled has been incorporated in both the main body of the report and its associated appendices.

6. Pages 23 through 28, Section D (Risk Characterization), Tables 5 through 8 ("Carcinogenic and Noncarcinogenic (Hazard Index) Risk Summary for.. . [Site] ").

Comments:

a. The carcinogenic risk estimate values presented in these tables all fall in the range of E-9 to E-7, indicating very low risk associated with exposure from various pathways and various contaminants of concern. The casual reader may not be aware that these derived risk values are not exact numbers and have a high degree of variability associated with them.

As noted in Section V (Health Risk Assessment), subsection D (Risk Characterization), paragraph 2 (Cancer Risk), the excess lifetime cancer risks are obtained by multiplying the intake rate/intake concentration of the contaminant of concern at the exposure point by the contaminant's cancer slope factor/cancer unit risk factor. Consequently, the intake is determined by the appropriate exposure pathway intake equation, for example:

$$\text{Intake (mg/kg - day)} = \frac{CA \times IR \times CF \times ET \times EF \times ED}{BW \times AT}$$

for the inhalation pathway, as given on page 17.

Most of the variables in the intake equation are constant (assigned default values), including IR, CF, ET, EF, ED, and BW. Thus, it becomes obvious that the "CA" and "AT" parameters are really the two variables which influence the outcome of the calculation. Moreover, the averaging time (AT) exerts the greatest influence in the outcome of the intake equation, as it is one of only two variables in the denominator. This being the case, the AT is a critical value which may change the intake value considerably. The value adopted for the AT may change the ultimate risk estimate by orders of magnitude.

b. The AT value adopted is dependent on a number of assumptions made by the risk assessor. EPA guidance allows that many of the assumptions must be made "according to the best professional judgement" of the risk assessor. However, it is important that the assumptions used to derive the AT be clearly explained and adequately defended.

The AT values used for various exposures, such as from "particulate inhalation exposure" are never clearly stated or adequately defended in this document. Since these assumptions ultimately determine the magnitude of the risk estimates, documentation and explicit discussion is warranted.

USAEHA response: The AT values used in the assessment were defined in the pathway exposure intake formulas. We neglected to inform the reader that the AT values used were the standard EPA lifetime default values for carcinogenic risk and 30 days for noncarcinogenic risk. These values are thoroughly discussed in the final report.

7. Pages 23 through 28, Section D (Risk Characterization), Tables 5 through 8 ("Carcinogenic and Noncarcinogenic (Hazard Index) Risk Summary for. . . [Site]").

Comments:

a. Tables 5 through 9 summarize the total carcinogenic and noncarcinogenic risks estimated for five of the sites monitored. The air pathway (vice the ingestion or dermal pathways) drives both the carcinogenic and noncarcinogenic risk at each site. For all sites, the carcinogenic risk driven by exposure resulting from the inhalation of metals, volatile organics and polycyclic aromatic hydrocarbons; for all sites the total hazard index (noncarcinogenic risk) is driven by exposure resulting from the inhalation of metals.

Although a large volume of data is included in this report, the data that is most significant to the assessment of risk, e.g., the air sampling data, is not provided. Annex B-S ("Site Specific Pollutant Concentration Summaries") provides only site specific air pollutant concentration summaries; the summaries provide only pre-calculated "means" and "upper 95th percentile" (95% UCL) concentrations representing the reasonable maximum exposure.

Because a significant amount of data is provided in the report, it may not be realized that actual air sampling data has not been included. However, on close scrutiny of the report it can be seen that the largest volume of "raw data" provided in this report is the quality assurance data provided in Appendix E (Analytical Methodology and Quality Assurance). Thirty-five tables, (Tables E-l through E-35) and 167 pages (pages E-12 through E-179) are devoted to presenting this quality assurance data. Soil sampling results are provided in Tables C-14 through C-22 of Appendix C; comparative metals results are presented graphically in Appendix B, but air sampling results are not provided, other than in graphically illustrated "monthly summaries" presented in Figures B-18 through B-33. As previously stated, it is reasonable that "raw data" tables were not included; however, the lack of a complete analytical data base precludes review and judgement associated with many of the observations made concerning air sampling.

USAEHA response: Notwithstanding the above comments, the USAEHA chose not to include the entire validated database files for all sample media in the interim report. All the validated database files, excluding the acid gas and mercury database files, have been input into Informix database files on a Unix-based geographical information system (GIS). AU combined, the ASCII database files comprise approximately 1.5 megabytes. The USAEKA soil sampling database files comprise approximately 0.3 megabytes. As of this date, the USAEHA is not able to provide these validated database files. When the release restriction is rescinded by The Office of the Surgeon General, the USAEHA will be able to provide all the validated data.

b. The risk associated with the inhalation exposure pathway includes exposure to particulates. An EPA reference dose (RfD), which is required to derive quantitative risk estimates under CERCLA guidance, has not been determined for total or respirable

particulates; therefore, risks associated with inhalation of particulates may only be addressed qualitatively. The text does contain some statements relaying information about the health concerns associated with inhalation of particulates but these are included in a number of different report sections; for example:

- Section V (Health Risk Assessment) (page 15) qualitatively states "The inhalation of airborne contaminants produced by the oil fires and oil lakes has a potential impact on DOD personnel throughout the theater."

- Appendix A-3 contains a toxicity profile on particulates which contains a discussion of inhaled particulates and human respiratory health.

- Section B (Source Characteristics) of Appendix B (page B-26) states "Atmospheric concentrations were of concern during this survey." It further states that specific concerns centered on potential amplified respiratory ailments because of high respirable particulate levels.

- Section VI (Discussion of Exposure Data and Trend Analysis) (page B-53) discusses the results of respirable aerosol particulates with an aerodynamic diameter of less than or equal to 10 microns (PM_{10}) and total suspended particulates (TSP).

Although these "statements" are made in various sections of the report, it is nowhere clearly stated that particulate inhalation may present the most significant health risk associated with the environmental contaminants of concern. The particulate sampling results presented in Table B-9 (page B-54) indicate that some of the air particulate sampling results are significantly above the primary U.S. National Ambient Air Quality Standard (for PM_{10} the standard is 150 $\mu g/m^3$ (24 hour)). Most of the results shown cm Table B-9 are an order of magnitude above this standard. This is not clearly pointed out.

USAEHA response: Accepted. For the final report, the USAEHA has expanded comparisons of the PM_{10} levels to include the "significant harm" and National Ambient Air Quality Standard PM_{10} threshold values.

c. The significance of the particulate sampling results is not discussed in the "Uncertainty Analysis" section of this report (page 29, subsection E). EPA risk assessment guidance requires discussion of uncertainties in risk associated with risk from contaminants of concern that cannot or are not included in the quantitative risk assessment. Investigations conducted under the IRP are required to include such discussion of contaminants of concern which present "non-quantifiable" risk. In view of the fact that particulate inhalation may present the highest contribution to health risk associated with the exposures in Saudi Arabia, it is of the utmost importance that this aspect of exposure and risk be adequately addressed.

USAEHA response: **Accepted.** A discussion of the qualitative risk associated with the particulate exposure has been incorporated in the final report.

8. Page B-60, Section VI (Discussion of Exposure Data and Trend Analysis), subsection entitled "Particulates, Metals and PAHs Data (High-volume TSP/PM_{10} Method 12), paragraph 2.

Comment: This paragraph addresses sampling methodology for the three different methods used to collect air samples for PAH analysis. The text states "These methods included a low-volume method using PUP and XAD-2 sorbent (modified method TO-13); the high volume TSP/PM_{10} particulate sampling method using quartz-or glass-fiber filters; and the high-volume TO-13 method using XAD-2 sorbent...Samples collected with the first two methods will be discussed below."

The sampling results associated with the high-volume TSP/PM_{10} sampling devices are presented in Tables B-5-16 through B-S-27 in Annex B-S. The results of the low volume method, using PUP and XAD-2 sorbent, are presented in Tables ES-36 and B-S-37. However, no mention is made as to whether particulate phase and vapor phase sample results were summed, or whether the results will be summed to determine the remaining data sets, not presented in this report. Thus far, the results for vapor phase analysis from the collection of PUP and XAD-2 sorbent analytical method notes that "all concentrations represented above represent "below detection limit values (one-half the detection threshold used for reporting purposes).' Therefore, at this time the addition of these two phases may not be important. It should be emphasized that samples should be summed from both phases to calculate a total PAH concentration. Furthermore, the XAD and PUF sample data should be added to obtain a single vapor phase concentration; since together, both volatile and low volatility PAHS are collected on these media. Section 5 (Ambient Air Sampling) of Appendix B (page B-37) also addresses the sampling methods that were used for PAHS. It states that "for the PUF/XAD-2 samples, recommended sample volumes were not able to be achieved by running the media in series, so the two adsorbents were run side by side in co-located fashion."

Section 5 (Ambient Air Sampling) of Appendix B (page B-37) also addresses the other method (EPA TO-13) used to sample PAHs. The text states that the filter media was not used during the sampling because sufficient volumes of air could not be collected. These were the samples for which results were not presented in this document. These samples would have been ideal for establishing the total PAH results; however, in the absence of the filter media particulate results, summation of these results to the high-volume vapor results already presented should be considered. Risk associated with PAH inhalation should be assessed on the basis of the summed value for PAH concentration and dose, not on the basis of fractional components of the dose.

USAEHA response: Rejected. The concentrations and doses were based upon summed values. Additionally, CCSEM, TEM, and other modalities were used to avoid underestimation of the PAH fraction. In the final report the carcinogenic equivalence factor of the various PAHs is used to compute the risk summaries.

9. Pages 17-18, Section V (Health Risk Assessment), subsection B (Exposure Assessment), subsection 3 (Quantification of Exposure).

Comment: Concentrations used to calculate exposure point concentrations (i.e., the contaminant "dose") associated with the inhalation, soil ingestion, and soil dermal contact routes are provided. As pointed out in the text, there is a different "chemical intake equation" for each of these exposure routes. However, the assumptions used to derive "averaging time" are not stated or discussed. This is significant because the exposure point concentrations are to be compared to subchronic RfDs/RfCs to derive the hazard quotient. Although not presented as such, the calculations presented list the specific equations to be used for calculating carcinogenic risks; the averaging time (AT) listed is for carcinogenic effects.

On page 41, the text includes a description of the averaging time used for the exposure point concentrations associated with noncarcinogenic health effects. It should be noted that this derivation of "averaging time" is atypical, relative to standard EPA guidance.

The text states that "The noncancer risk levels for each month were calculated and the risks for the total exposure period was obtained by averaging the risks for the individual months of exposure. An attempt was made to obtain the values listed on Table A-2-56 (Hazard Indices (HI) for ingestion of Soil at Khobar Towers...) by employing equation (2) for ingestion intakes for chemicals in soil and using a value of approximately 30 days (0.083 year x 365 days/year) for AT. It appears that either: (1) the difference in noncarcinogenic vice carcinogenic application of the ingestion intake equation, for chemicals in soil, differ by more than the AT value used; or (2) inaccuracies exist in the results presented on Tabk A-2-56.

Additionally, although the text may address the assumptions made for the noncarcinogenic exposure point concentrations, since the values were not presented in the equations, it may appear to some readers that an "under conservative" estimate of the hazard index is the bias of the risk assessment.

USAEHA response: Accepted. A discussion of each assumption and intake value used in the various equations is included in the final report.

10. Page 31, Section V (Health Risk Assessment), subsection E (Uncertainty Analysis), paragraph 4; and Appendix A, page A-3-16, Section entitled "Polynuclear Aromatic Hydrocarbons (PAHs)..

Comment: The text states that 'all polycyclic aromatic hydrocarbons (PAHS) were assessed as benzo-a-pyrene, the most carcinogenic (based on the slope factor) PAH detected." The paragraph further states that "this procedure provides a conservative estimate of the carcinogenic risk contribution of the PAHS. Using a conservative approach to the HR is an accepted practice, however, the rationale also should be realistic. It may be useful, for comparative purposes, to list the risk values obtained from a less conservative (more realistic) risk characterization approach as well. It may be more realistic to calculate the total carcinogenic fraction of PAHs and assess that fraction as benzo-a-pyrene. The Appendix A section, noted above, separates the specific PAHs sampled into those that demonstrate some degree of carcinogenicity and those that are noncarcinogenic.

USAEHA response: Accepted. This is the methodology used in the final HRA for the PAHs.

11. Page 37, Section XIII (Discussion of HRA Results), subsection A (Cancer Risk Levels), paragraph 3.

Comment: e sentence in this paragraph describes the use of a correction factor by which the risk level was multiplied to equalize the risk with respect to the duration of exposure, since monitoring was accomplished during different periods in time. On Table 11 (Equalized Cancer Risk Levels for the Seven Monitoring Sites), multiplication factors are shown for the seven monitoring sites. If this is done simply for comparison purposes it may have validity; however, the risk levels do not have to be equalized for the purpose of the health risk assessment (HRA). The risk calculations should be as site-specific as possible, and if the exact duration of exposure is known, it should be used to calculate the HRA.

Since the "equalized" risks were not the values presented in the carcinogenic and noncarcinogenic summary tables, it appears that the purpose of carcinogenic risk equalization is limited to the presentation of a hypothetical situation of an equal exposure duration for each of the monitoring sites. Also, it should be stated that tk multiplication factors employed for the "equalization" process did not change the risk significantly (i.e., there are not orders of magnitude differences).

USAEHA response: xAccepted.ion of the use of the equivalency factors is contained in the final report.

12. Appendix A, Page A-2-3 (Inhalation Carcinogenic and Noncarcinogenic Exposures and Risk Summary Tables), Tabk A-2-2 ("Khobar Towers, Inhalation Noncarcinogenic Exposure and Risk Summary, May 1991, Reasonable Maximum Exposure (RME)").

Comment: This is the first of many tables which lists the subchronic inhalation reference concentrations (RfCs) for m-, p-, and o-xylene as 7.0E-1, 3.0E-1, and 7.0E-1 mg/kg-day, respectively. These three values are different than any of the "health effects criteria" values provided in the EPA document "Health Effects Assessment Summary Tables" (HEAST). The 1991 HEAST provides both chronic and subchronic RfC values for m-, p-, and o-xylene. The values presented in this table are neither HEAST chronic or subchronic values, thus it is difficult to determine from where they were derived. Additionally, Table A-3-2 ("Reference Doses"), lists the RfC for all three isomers of xykne as 2E-1 mg/kg-day, which contradicts the values presented in this table.

The 1992 HEAST lists the subchronic RfD for m-, and o-xylene as 4E+O mg/kg-day; an RfC is not given. Thus, it is quite confusing as to how the particular subchronic RfCs for the xylene isomers were derived for this study. The derivations for the RfC values are not provided or discussed in the report. Xykne is illustrated here as just one example; references for the sources of the other contaminant reference doses need to be provided as well;

USAEHA response: Accepted. Complete references for all toxicity factors used in the HRA is included in the final report.

13. Appendix A, Page A-34, Table A-3-l ("Carcinogenic Slope Factors.. .").

Comment: The oral slope factor for benzo(a)pyrene is listed as 1.15E+l; the inhalation slope factor is listed as 6.1E+0. An EPA Region 10 "Special Notice,' dated 10 July 1992, disseminated information concerning a change in the Integrated Risk Information System (IRIS) oral carcinogenic potency value for benzo(a)pyrene. The correct value for oral potency is 7.3 per (mg/kg)/day (and the drinking water unit risk is 2.1E-4 (μg/L)). The EPA notice further comments that revision may not be necessary to draft and final risk assessments recently or currently being developed because the corrected value represents only a small change in magnitude (approximately 20%). However, since this is a preliminary risk assessment, the change should be incorporated before the final draft is developed.

USAEHA response: Noted. All values used for the contaminants of concern have been revalidated as of December 1993 and their sources identified.

14. Appendix D, Page D-5, Section 6 (Sampling Results), Tabk D4 ("Industrial Hygiene Results, Average Values, mg/m³") and Table D-6 ("Maximum Sample Results, Data Reported as mg/m³").

Comment: Table D-4 shows what appears to be a significant difference between the average nitrogen dioxide concentrations observed in Kuwait (1.65 mg/m³) vice Saudi Arabia (0.40 mg/m³). The standard deviation for the Kuwait data is 1.30 vice 0.24 for the Saudi Arabia data. Table D-6 reports the maximum nitrogen dioxide result as 6.70 mg/m³ and presents the American Conference of Governmental Industrial Hygienists Threshold Limit Value of 5.6 mg/m³ for comparison purposes. The text does not specifically address the high nitrogen dioxide concentrations, the implications of the high variability of nitrogen dioxide data or health risks related to potential exposures.

USAEHA response: Rejected. Paragraph 6-c, page D-8, stated that the average results of the pooled Kuwait and Saudi Arabia data showed no statistically significant difference between the two areas, and that the average results never approached an occupational health standard. The maximum sample result listed in Table D-6, page D-8, for NO_2 is a one time hit, the highest sample value seen in the study. Furthermore in paragraph 7-c on page D-9 the statement is made that the magnitude of exposures was low compared to recognized occupational health standards. It also states that adverse health effects would not be expected based on the assumptions inherent in such standards.

15. Appendix G, Page G-4, Table El ("Identification and Observations of As-Received Samples").

Comments concernig observations for many of the filter samples submitted for air analysis by electron microscopy relayed that filters were only partially intact when received (e-g., one of the observations made for AEHA ID#133-01(H) is "approximately one-quarter of original filter received'). The table indicates that only 7 of 58 samples were received intact. This appears to make the integrity of the sample results highly questionable.

This is not discussed in the text nor is it stated whether or not adjustments were made in calculations as a result of only receiving a portion of the filter. The uncertainty section does not address this issue. Additionally, these comments raise concerns regarding the integrity of the other air samples collected on filters.

USAEHA response: Rejected. The response to this comment was provided by Mr. Gary Cassucio of the RJ. Lee Group, Inc.

With regard to Ms. Lunsford's concerns on receiving samples which were only partially intact, I believe this is just a simple misunderstanding. We documented receiving only a portion of the sample in many cases because other analyses were performed on other portions, or because they were archived for potential future use. This is a common practice and should not have an adverse affect on the results, assuming the sample was uniformly loaded with particulate matter. Our review was performed simply to document the condition and amount of sample received.

For further explanation of the analyses used by the RJ. Lee Group, Inc. the commentor is referred to the response provided to Dr. Mulholland od the National Institute of Standards and Technology.

16. Addendum: Appendices and Annexes.

Comment: Although only a proof-reading comment, it should be pointed out that the organization of the many appendices in the report is very confusing. Appendices A through F (pp. B-1 through F-31) exist in the back of the report body, with Annexes B-1 through B-6 placed at the end of Appendix B (pp. B-1-1 through B-6-2). In addition, another set of appendices, A through H, are presented at the very end of the report (pp. A-1 through H-27). The former "Appendices A through F" and Annexes are not listed in the Table of Contents. In its present state, readers find it extremely difficult to refer to the tables and information contained within these sections.

USAEHA response: Accepted. We have attempted to compose the vast array of information, tables, and figures in a more reader friendly format in the final report.

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FROM: OD-CA 19 November 1992

SUBJ: Review of Interim Kuwait Oil Fire Health Risk Assessment

TO: HQ AFMC/SG
HQ AFMOA/SGPA
IN TURN

1. Thank you for the opportunity to review this document. Given the circumstances, the Army assessment team has done a commendable job. The risk from the oil fires was minor in comparison to risks generated by local conditions, in particular those due to chrome. The chrome risk in itself is quite small, and may be less than predicted if species can be determined. It is doubtful that disease from these exposures, presuming any will occur, will ever Teach measurable levels.

2. The limited ability of this report to answer questions regarding true risk results from external factors beyond the control of the authors. The limitations reside primarily in biological and environmental modeling inadequacies, the limited biological meaning of sampling data as currently collected, and shortfalls in collection and analytical technics. In addition, the need to answer questions of this nature has come from recent cultural changes in our country. Sufficient time has not passed to make the appropriate infrastructural and procedural changes necessary to allow pro-active collection of the necessary data and ready interface of that data with other DOD databases such as personnel rosters, unit geographic locations and medical records.

3. Data regarding local conditions was not collected in real time at all locations. Thisforces reliance on retrospective modeling to describe what likely conditions were. There is considerable uncertainty at the small scale in this process, and the small scale is exactly where people are exposed. The uncertainty generated by the performance capability of atmospheric models at the fine scale has its counterpart in the application of measured data collected at one point and made to represent the exposure over a relatively broad area. Neither system is perfect, and only general conclusions can be drawn. The biological meaning of environmental sampling as that relates to dose is not at all well worked out. Cancer risk can change substantially depending on the model used. Much work needs to be

done on the meaning of short term exposures with regard to cancer. Resent models do not address this question well. Behavioral factors must be included in such studies in the future, since it is apparent that they play a major role in health outcome studies. Of all the possible health outcomes, behavioral outcomes are the only ones to have sufficient prevalence and incidence on a routine basis to allow meaningful studies on small numbers of people (500 to 1000). Many of the laboratory and physical measures used for assessment of acute and chronic biologic change are too coarse to act as measures of change in the face of minimal exposures. Others are simply indicators of exposure, not necessarily specific exposure, and are not markers of disease. Combine them with the uncertainties and inadequacies in cancer and weather modeling and projections become very uncertain.

4. It seems likely that we will be faced with the collection of similar kinds of data ...Please note that this section of Dr. Poitrast's comments was undecipherable, and attempts to reach Dr. Poitrast for clarification were not successful... If the research, administrative, and functional structure to accomplish the task had been in place prior to the war, it would have been much better.

5. In conclusion, I believe that this study has developed sufficient information to conclude with reasonable medical certainty that the oil fires in Kuwait are not likely to be a major source of illness for DOD personnel. It is not likely that the addition of the factors for dermal contact and absorption will change this conclusion.

BRUCE J. POITRAST, Colonel, USAF, MC
Associate chief Scientist
Occupational Health and Environment

USAEHA response: COL Poitrast's comments are noted.